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Economic Evaluation of Wood Chip Production Alternatives for P.E.I.

by

IEA Consulting Group Ltd.

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by

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ECONOMIC EVALUATION OF WOOD CHIP

PRODUCTION ALTERNATIVES FOR P.E.I.

BY

IEA Consulting Group Ltd.

Executive Summary

0.0 Overview

The objectives of this study were to examine the wood fuel supply systems on P.E.I., to recommend improvements in the existing systems and to analyze the feasibility of establishing a centralized wood chip terminal. Analysis of the projected markets, the major supply systems outside P.E.I. and the suitable wood chip supply businesses was performed to support the above objectives.

0.1 Demand

The Provincial and Federal Government are supporting development of the wood chip industry on P.E.I. At planned levels of funding, annual demand for wood chips of 8600 ODt by 1985/86, 56,000 ODt by 1990 and 110,000 ODt by the year 2000 has been forecast based on present government budgets and policy. Considerable acceleration of the market growth is possible if oil prices rise or incentives are provided. The forecast demand by the year 2000 would be distributed in a market of 40,000 - 50,000 ODt in Charlottetown, one of 30,000 - 40,000 ODT in Summerside, and four smaller markets, ranging from 2000 - 8000 ODt each. Ceiling prices of $68/ODt for the residential market

and $63/ODt for the non-residential market were expected based on 1984 oil prices.

0.2 Supply

At present levels of forest growth, a total annual sustainable biomass supply of 205,000 ODt/yr was forecast. An additional 15,000 ODt/yr of sawmill residue is produced, much of which may have increased value as particulate fuel. The forecast supply within 50 km of the major markets and within 20 km of the smaller markets is expected to be sufficient to meet forecast demand.

0.3 Existing Production Methods

At existing levels of production, only one P.E.I. supplier is producing chips at an average price below the expected ceiling price. Significant investment in harvesting and transportation equipment will be required for contractors to produce high volumes efficiently.

Medium to large scale systems outside P.E.I. are producing chips at costs of less than $50/ODt, excluding the costs for storing and handling the chips. Many of the above systems are supplying pulp mills and other large consumers where seasonal demand factors are not as significant as they are projected to be under P.E.I. conditions.

0.4 Chip Production Equipment and Facilities

The chip production equipment which is technically and economically most attractive for P.E.I. is listed below:

1. Medium-scale mobile chippers with attached chip bins are attractive for small-scale production and thinning operations.
2. Large-scale mobile chippers with attached chip bins are attractive for large-scale production during periods when woodlots are accessible.
3. Forwarding equipment with racks or clam-bunks is attractive for forwarding in cold-decking operations.
4. Large-scale, truck-mounted chippers with attached loaders are the most flexible for roadside chipping.
5. Container delivery systems offer the most cost effective transportation system for low volume production and long hauls.
6. Large volume dump trailers are cost effective for medium hauls and high volume chippers.
7. Modification of standard 12-15 m trailers can be the most cost effective method for transporting unprocessed residues on most hauls on P.E.I.

Very large volume chippers, chip vans and truck-trains are not expected to be suitable for production from small to medium woodlots over the relatively short hauls on P.E.I.

Storage and handling are a critical component of chip costs, and, therefore, must be minimized. Storage in cold-decks at roadside is the most economical alternative; however, some

central storage is required for winter conditions when woodlots and clay roads are inaccessible. Covered storage of chips is expected to be the most economical for medium and large operators. Whole-tree storage is expected to be the most economical for wood terminals where investment in large scale handling equipment is feasible. Outdoor storage of chips in large piles may be economical for storing large volumes of chips for short periods.

0.5 Chip Production Systems

Four possible chip production businesses were evaluated to determine estimated prices which yield an attractive return. The results are summarized below:

	Integrated Sawmill	Medium Contractor	Large Contractor	Wood Chip Terminal
Investment	$52,000	$260,000 to 275,000	$665,000	2,320,000
Capacity ODt/yr	950	3,500	10,000	40,000
Price/ODt for 25% A.T. Return	$44	$55-61	$54	$53
(Per 45% M.C. ton)	($22)	($28-31)	($27)	($27)

Prices are based on wood purchase at $21/ODt at the stump and $23/ODt at roadside. Reductions in these costs affect ceiling prices by the same amount. Costs can also be reduced $2-3/ODt if covered storage can be eliminated for the large volume suppliers and $3-4/ODt if the terminal can be integrated with a single large consumer.

0.6 Summary

In conclusion, small scale chip production is not expected to produce chips at prices lower than $63/ODt. Chip prices of $55-61/ODt are expected from Medium Contractors and $54/ODt from large contractors with efficient operations. The additional risk involved in operating large chip terminals is expected to outweigh the marginal price reduction achieved relative to the large contractor. Integrated sawmills which produce chips as a byproduct are expected to supply the lowest cost chips; however, slab capacity is limited.

1.0 Introduction

Wood fuel has been identified as the only major, viable alternative to oil for space heating requirements on Prince Edward Island. Recent projects have been initiated in order to improve forest management practices on Island woodlots and to stimulate market development by converting a number of boilers for institutional buildings to wood chip fuel. Further expansion of the wood chip market is forecast for the future.

This study was conducted to analyze the major alternatives for producing wood chips on Prince Edward Island. The production system is defined to include all the activities required to convert wood from the stump to chips in the customers' delivery bin. The objective was to identify commercial production units that are expected to be economically viable on their own or in conjunction with existing enterprises. The variables which indicate viability include price, production volume, cost and return on investment.

The analysis of appropriate chip production systems was based on the characteristics of the forest industry on Prince Edward Island, many of which make it unique in Canada. First, 90% of the resource is owned by approximately 12,000 land owners with woodlots ranging from less than 1 ha to more than 100 ha. Second, the major forest product is fuelwood which has an annual consumption greater than that of sawlogs and pulpwood combined. Limited growth is expected in the fuelwood market because the residential market is becoming saturated and the conversion of

larger sites is typically unattractive. Third, all pulpwood production is exported which results in limited returns to the producers and value added to the Province. Finally, all of the woodlot soils and many of the roads are clay based which makes access difficult or impossible for two or three months every year.

A small wood chip industry already exists in the Province. The industry consists of conventional silvicultural, sawlog and pulpwood firms which have diversified into low volume wood chip production. The major barrier to expansion has been the lack of a large, secure market for chips. At the same time, market growth has been inhibited by the lack of a secure supply of low cost chips. With the completion of projects presently in progress a satisfactory base load should be established. Expansion potential would then exist through aggressive marketing to commercial, institutional and residential consumers. The existing harvesting companies have the skills and some of the equipment required for expansion. The major investment and expansion requirements are in chipping, transportation and storage facilities.

Please note that all measures of mass in this report are quoted in oven dry tonnes (ODt). See Appendix 7 for the conversion factors used.

2.0 Objectives and Organization

The specific objectives of this project were to:

1. Examine the wood fuel supply systems currently in use on P.E.I. and to make recommendations regarding how producers can lower costs, increase markets and improve returns.
2. Analyze the economics of establishing a centralized wood chip terminal.

The report is organized to include an analysis and evaluation of:

1. The present energy markets and projected wood chip demand.
2. The supply of biomass for wood chip production.
3. The present chip production systems used on Prince Edward Island.
4. Major wood chip production systems used elsewhere in North America and in Scandinavia.
5. The harvesting, chipping, transportation and storage modules which could be implemented on P.E.I.
6. The chip production systems suitable for supplying the projected market.

The above evaluations are used to determine suitable chip-delivery systems for the province.

3.0 Wood Fuel Demand

The development of the wood chip industry in Prince Edward Island will be based on the substitution of conventional fuels by wood chips and related products. This section examines the total demand for energy, the present demand for wood fuel and the expected growth of the wood chip market on Prince Edward Island.

3.1 Provincial Energy Consumption

Table 3.1 summarizes the 1983 consumption of energy for purposes other than transportation. The table lists gross fuel energy consumed from petroleum products, electricity and coal by major sectors as reported by Statistics Canada (1984). Wood energy consumption was estimated from known markets for round-wood, chips and sawmill residues.

With present technology, wood chip fuel substitution will be most competitive in the space heating and hot water heating markets. Other markets, such as electrical cogeneration are presently being evaluated but are beyond the scope of this report.

For comparison purposes, the fuel consumption should be adjusted to reflect differential combustion efficiencies. Table 3.2 summarizes the estimated net usable energy produced for heat generation by fuel type and sector. Electrical consumption for non-residential users is used primarily for lighting, mechanical and other applications where heat generation is secondary and has therefore been excluded. Approximately 40% of residential electrical consumption is used for hot water requirements and the

very small market for electrical space heat (Middleton and Associates 1980). The remaining electrical consumption is used for lighting and other applications and has therefore been eliminated. Table 3.2 indicates that a total market for heat generation of 6 petajoules exists on P.E.I. which is equivalent to the consumption of approximately 500,000 ODt of wood (see assumptions in Table 3.2.)

(i) The Residential Market

The residential market is the largest consumer of energy for heat production and uses 57% of the total heat produced. Residential users are also the only large consumers of wood energy using 98% of the energy generated from wood fuel. Wood fuels provided 28% of residential heating requirements in 1983. Virtually all of the wood was consumed as roundwood or blocked slabs.

Residential consumption of energy is very seasonal. Most of the energy for space heating is required between late September and early June.

(ii) The Commercial/Institutional Market

Petroleum products provide 81% of the heat energy required by commercial and institutional consumers. The demand for wood fuel results from a number of recent institutional and commercial plant conversions. Coal is used in a large fluidized bed boiler at the Canadian Forces Base, Summerside.

Table 3.1. Non-Transportation Energy Consumption on Prince Edward Island by Sector, 1983.[1]

	Gross Terajoules					
	Petroleum Products	Wood	Electricity	Coal	Total	%
Residential	2804	2000	622	-	5426	56
Commercial/ Institutional	1651	27	739	352	2769	28
Industrial/ Agricultural	787	11	341	-	1139	12
Utilities	385	-	-	-	385	4
Total	5627	2038	1702	352	9719	100
%	58	21	18	4	100	

1 Excludes Motor Gasoline and Diesel Fuel Oil for stationary applications.

Sources: Statistics Canada 1984, Resource Ventures Inc. 1983, IEA Estimates.

Table 3.2. Adjusted Energy Produced for Heating Requirements by Sector, 1983.

	Net Terajoules					
	Petroleum Products	Wood	Electricity	Coal	Total	%
Residential[1]	2187	962	249	-	3398	57
Commercial/ Institutional[2]	1321	16	-	289	1626	27
Industrial/ Agricultural[2]	630	6	-	-	636	11
Utilities[2]	308	-	-	-	308	5
TOTAL	4446	984	249	289	5968	100
%	75	16	4	5	100	

1 Wood at 30% M.C., 55% furnace efficiency; oil at 78% efficiency; 40% of electricity used for heating at 100% efficiency.

2 Wood at 45% M.C., 70% furnace efficiency; oil at 80% efficiency; coal at 82% efficiency.

Although Commercial and Institutional fuel consumption is used primarily for space heating from September to June, a number of commercial and institutional consumers such as hospitals and laundry facilities also have significant energy requirements during the summer months.

(iii) The Industrial/Agricultural Market

Petroleum Products provide 99% of the heat energy required by industrial and agricultural users. The demand for wood fuel results primarily from a company which utilizes wastes from its window mill for energy in its offices, mill and concrete plant. Wood is also used in the drying kilns of two tobacco operations and in the boiler of a commercial greenhouse.

The consumption pattern varies greatly depending on the application. Fish and food processing plants require high levels of heat during the period from late June to October. Winter requirements range from negligible for seasonal plants to high for plants that operate year round. Applications such as tobacco drying consume all their energy requirements from August to October. Other industries which use energy for space heat have seasonally high consumption during the winter.

Maritime Electric has oil fired electrical generating facilities. The generators are currently used to provide backup and peaking capacity which results in sporadic energy consumption. The present costs of wood fuel are greater than the value of the electrical energy that could be produced (Brown and Wells 1983).

(iv) Geographical Distribution

Figure 3.1 outlines the approximate distribution of existing energy consumption for heating purposes based on:

1) Population centres with more then 1000 gross tonne equivalent residential consumption.

2) Residential consumption at 78% efficieny for oil, 55% furnace efficiency for wood burned at 30% M.C.

3) Non-residential distribution based on boiler installations for commercial, institutional and industrial sites with greater than 20 hp total site capacity, greater than 1000 gross tonne equivalent local consumption.

4) Industrial consumption at 80% efficiency for oil, 70% furnace efficiency for wood burned at 45% M.C., estimated 40% overall average load factor.

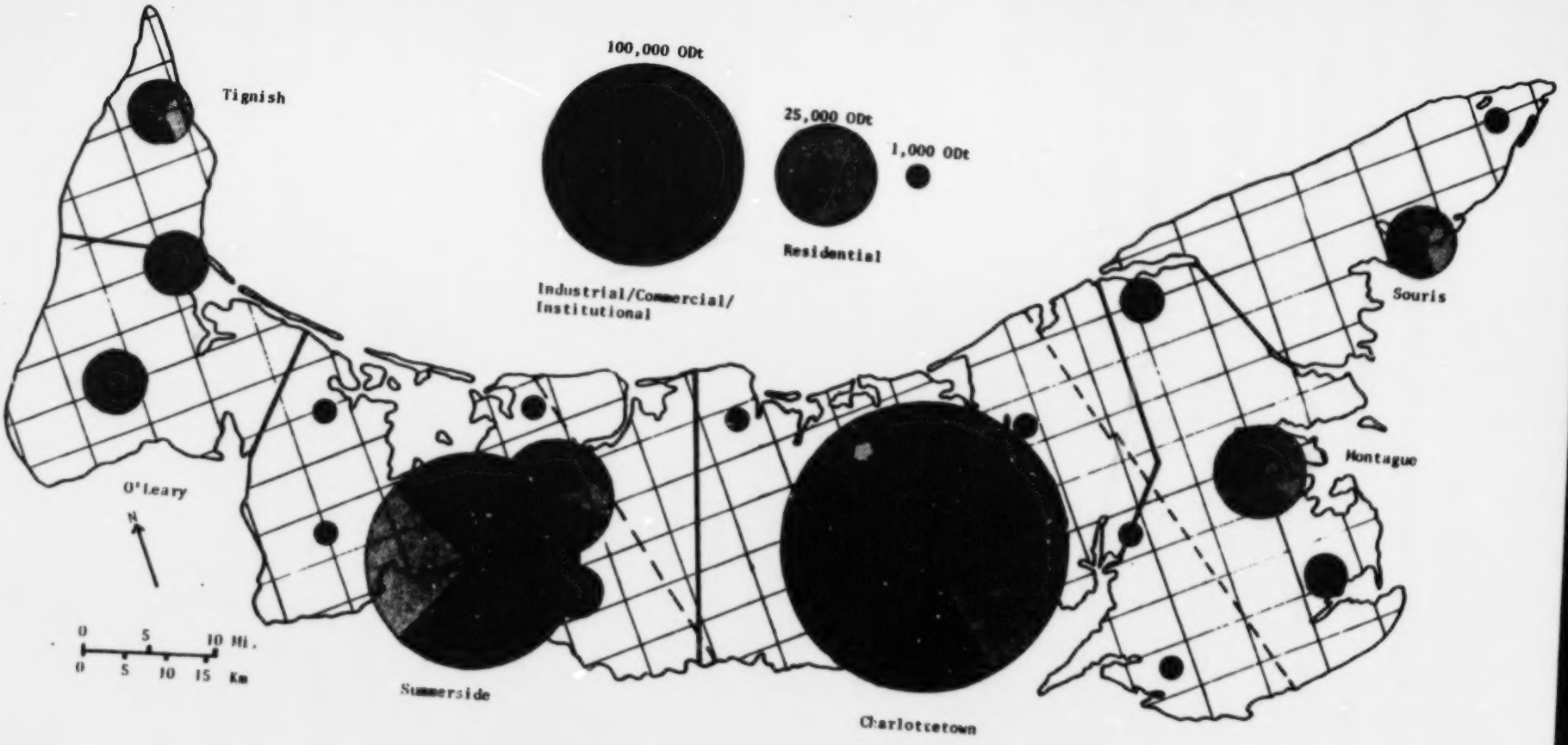
The detailed calculations and additional assumptions are contained in Appendix 1.

Figure 3.1 clearly indicates the concentration of energy demand in the Charlottetown and Summerside areas. The markets in Tignish, O'Leary, Montague and Souris are significantly smaller but may be suitable for small contractors. Other markets exist in small towns and dispersed non-residential sites which may be attractive for local producers.

3.2 The Wood Chip Market

The present wood chip market exists primarily as a result of a number of government financed installations. The future market for wood chip fuels will be determined primarily by the attractiveness of converting to wood from petroleum products. The substitution of electricity will be negligible because high electrical rates have prevented the use of electricity for space heat.

Figure 3.1. Estimated equivalent wood consumption for market areas with more than 1000 ODt equivalent industrial/commercial/institutional demand and more than 1000 ODt equivalent residential demand on Prince Edward Island.



i) The Residential Market

Approximately 60% of the 38,000 homes on Prince Edward Island presently use wood to provide some or all of their space heating requirements (Resource Ventures Inc. 1983). Most of the wood is consumed in the form of roundwood or blocked slabs; however, future growth in this market may be limited. A small percentage of homeowners burn sawdust, pellets and/or chips.

The demand for wood chips exists primarily as a result of a demonstration project carried out in 1981 involving 30 homes. The homeowners presently produce their own chips or utilze sawmill residues for heating requirements.

Major growth in the residential wood fuel market is expected to occur in the wood chip segment where furnace operation is generally more covenient and bulk deliveries by suppliers can be made directly to storage. For the purposes of this report, residential wood chip demand will be projected at a 50% annual growth rate for the next decade.

ii) The Commercial/Institutional Market

The present market for wood chips includes a number of government owned and one privately owned facility. The major sites which are presently operating or under construction are listed in Table 3.3. The demand for wood chips during the 1984/85 heating season is expected to be 2800 ODt if all plants operate satisfactorily.

Significant growth is expected in the commercial and institutional markets as growing chip markets increase security of supply and decrease prices. The incentives provided for

Table 3.3. Existing wood chip installations on Prince Edward Island including those presently under construction.

Site	Location	Estimated Consumption	Comments
U.P.E.I.	Ch'town	6000 ODt annually	Proposed for 1985/86
P.E.I. Hospital	Ch'town	1000 ODt 1984/85 3000 ODt annually	Scheduled for start up in early 1985
Kings County Memorial Hospital	Montague	1000 ODt annually	Operating since 1982
Energy From Waste Plant	Ch'town	0-500 ODt annually	Wood used as a backup fuel
Regional School	Abram Village	300 ODt annually	Operating since November, 1984
Regional School	Souris	300 ODt annually	Scheduled for winter 1985/86
Sleepy Hollow	Ch'town	200 ODt annually	Installed
Summerside Manor	S'side	200 ODt annually	Installed
Montague Junior High	Montague	100 ODt annually	Installed
Commercial Greenhouse	Montague	50 ODt annually	Installed

conversion are also expected to stimulate growth in the wood energy market.

One large project presently being considered is a district heating system for Charlottetown. If this project were to go ahead, it would create a large demand for chips in the Charlottetown area over a short period of time. Since implementation of this project is uncertain and start-up would begin no earlier than 1986, market growth in the Charlottetown area was assumed to be independent of whether the demand is from one large facility or a number of small sites.

iii) The Industrial/Agricultural Market

The present market for wood chips includes a company that supplies its requirements internally from its window plant and a commercial greenhouse operation.

The commercial greenhouse is the only operation that can utilize chips from conventional forestry operations. The demand for wood chips during the 1984/85 heating season is estimated at 50 ODt.

Significant growth is expected in the industrial market in parallel with growth in the commercial and institutional markets. One large project which has been under consideration for a number of years involves the conversion of the steam plant for a large food processor. The scale and implementation of the project is uncertain at this time and is therefore considered to be incremental to any projections made for the purposes of this report.

3.3 Wood Chip Market Forecast

The projected market for wood chips is outlined in Table 3.4 based on the following assumptions:

1) Annual growth of 50% per year in the residential chip market for the next decade.
2) Substitution of wood chips for 25% of present commercial, institutional, industrial and agricultural consumption for heat by 1990.
3) Substitution of wood chips for 45% of present non-residential consumption for heat by 2000.

Assumptions 2 and 3 are based on published government policy objectives and assume that planned levels of funding will be maintained.

The estimated geographical distribution of wood chip demand based on existing energy consumption patterns is outlined in Figure 3.5. The Charlottetown and Summerside areas are expected to provide over 80% of the future market. These areas have a large enough potential market for the development of a large scale supply system. The remaining areas can be expected to provide a suitable market for small and medium contractors.

Table 3.4. Forecast of Wood Chip Markets to the Year 2000

	Oven Dry Tonnes			
	1984/85	1985/86	1990	2000
Residential	150	200	1,000	10,000
Commercial/ Insitutional	2,750	8,000	35,000	65,000
Industrial/ Agricultural	50	400	20,000	35,000
Total	2,950	8,600	56,000	110,000

Table 3.5 Estimated Geographical Distribution of Wood Chip Demand to the Year 2000

	Oven Dry Tonnes				
Market Area	1984/85	1985/86	1990	2000	% (1990-2000)
Souris	-	300	1,500	2,900	3
Montague	1,100	1,200	4,000	7,800	7
Charlottetown	1,400	6,500	25,000	49,200	44
Summerside	450	600	21,800	42,800	39
O'Leary	-	-	2,700	5,300	5
Tignish	-	-	1,000	2,000	2
P.E.I.	2,950	8,600	56,000	110,000	100

3.4 Wood Chip Prices

For the purposes of this report, maximum market prices have been based on the following assumptions:

i) Residential users will not pay more for chips than 90% of the cost of processed roundwood (approximately $75/ODt). The increased investment cost of chip fueled equipment is assumed to be balanced against the increased savings and convenience at this level.

ii) Non-residential users will not pay more for chips than 50% of the market price of oil. The above margin will be required to cover investment and increased operating costs and to realize some savings.

Based on the above assumptions and the conversions outlined in Appendix 7, the ceiling prices for delivered wood chips in 1984/85 are outlined below. Ceiling prices represent the highest price at which it is still attractive to convert to wood chips. Expected prices are 80% of the ceiling prices.

	Maximum Prices		Expected Prices	
	ODt	45% M.C. Tonne	ODt	45% M.C. Tonne
Residential Chips	$68	$37	$54	$31
Non-Residential Chips	$63	$35	$50	$28

Prices are based on the average price of chips delivered in green condition to the customer's fuel bin. Actual prices will fluctuate with delivery distance, volume and other conditions. The above values are generally in agreement with economic analysis by IEA (1983) and Neil and Gunter (1983) adjusted to P.E.I. conditions.

3.5 Summary

Wood burned in roundwood form produced 16% of the space heat requirements in 1983. Expected expansion in the roundwood market is limited. The Provincial and Federal Governments are supporting further development of the wood energy industry through development of wood chip markets. At planned levels of funding, demand for wood chips of 8600 ODt by 1985/86, 56,000 ODt by 1990 and 110,000 by the year 2000 could be realized.

The major concentrations of demand will be in Charlottetown and Summerside with a number of smaller markets existing in other areas. During the next five years, two markets of 20,000-25,000 ODt and four of 1,000-4,000 ODt could be expected. The above markets are expected to double in size by the year 2000.

Estimated ceiling prices for chips are $68/ODt for the residential market and $63/ODt for the non-residential market in 1984/85 dollars. Expected prices are $54 and $50/ODt, respectively.

4.0 Wood Fuel Supply

The supply of wood fuel on Prince Edward Island comes from two major forest sources: sawmill residues and woodlot production. Sawmill residues are produced in four major forms:

1) Slabs, edgings and trim
2) Chips
3) Sawdust
4) Shavings

Slabs are a potential source of raw materials for chipping. Sawdust and shavings offer a low cost alternative to wood chips for fuel.

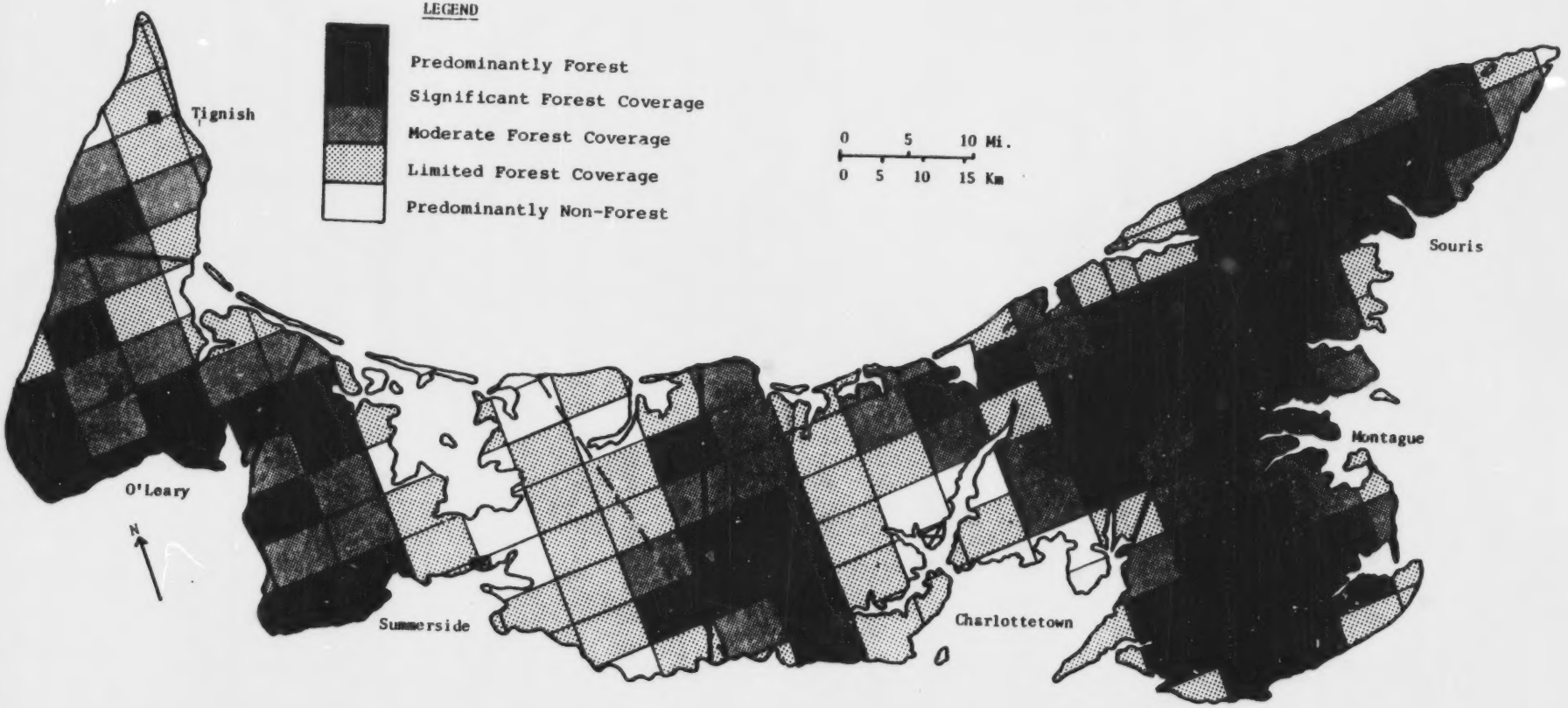
Potential sources of fuel from forest woodlots include:

1) Wood harvested from salvage operations, stands of non-commercial species and pulpwood operations.
2) Waste from conventional operations including tops, branches, cull wood and unmerchantable species.
3) Wood from silvicultural thinning operations.

Sawlogs and high value hardwoods have high market values which preclude their use in chip fuel production. The remaining products from woodlots including low grade softwood, poplar and pulpwood can have the highest value as wood chip fuel.

Detailed estimates of the quantities of fuel presently produced and consumed are provided in section 4.1 to 4.4. For the purposes of this report, the estimates are summarized for the regions outlined in Figure 4.1 which correspond approximately with the major population centres and natural boundaries in the province.

Figure 4.1. Distribution of Forest Biomass of P.E.I. (Adapted from Total Harvestable Biomass Map, P.E.I. Department of Energy and Forestry).



4.1 Sawmill Residues

There are over 50 sawmills operating on the Island which range in size from less than 120 cu.m (50 cords) to more than 7200 cu.m (3000 cords) in annual sawlog consumption.

Interviews were conducted with the operators of sawmills which consumed more than 480 cu.m. (200 cords) of sawlogs per year. The estimates of sawlog consumption were generally found to be in agreement with estimates provided in a survey by Spatial Planning (1982) and figures published by the Sawmill Association in 1981. Total consumption was lower because a number of mills have ceased operation since 1982. Quantities of waste were more difficult to verify. Island sawmills that have a market for residues typically sell their wastes in trailer loads, pickup truck loads and dump truck loads. Where available, residue estimates were obtained by multiplying the number of truck loads times the average truck volume for mills that delivered wastes and/or the volume of waste on site divided by the percentage of the years production to produce that waste. Where no estimates were available or the estimates were not considered to be reliable, residue production was estimated using the audit values reported in Spatial Planning (1982).

Estimated residue production and sales for Island sawmills are listed in Appendix 2 and summarized below in Table 4.1. The Available Biomass column provides an estimate of the quantities available for fuel. Actual values will vary significantly with market conditions, annual production and product mix. Residue prices were also obtained; however, specific prices were not

Table 4.1

Estimated Volume of Sawmill Residues Available for Fuel

From Sawmills With Greater Than 480 cu.m Annual Production

(Oven Dry Tonnes)

Region	Slabs[1]			Sawdust			Shavings			Residue Production	Surplus Residue
	Produced	Surplus	Price	Produced	Surplus	Price[2]	Produced	Surplus	Price[2]		
Souris	454	0	$22-24D	97	85	-	65	36	-	616	121
Montague	2548	6	8-44D	912	409	-	444	199	-	3904	614
Ch'town	2165	135	28-51D 14-21M	897	45	$26-44D 0-20M	355	40	$ 41D 14-32M	3417	220
S'side	2255	0	28-46D 11-27M	1015	141	41D	638	100	-	3908	241
O'Leary	1690	0	26-33D 3-5 M	877	510	-	77	37	-	2644	547
Tignish	360	0	17M	152	118	-	22	3	-	534	121
P.E.I.	9472	141		3950	1308		1601	415		15023	1864

1 Includes slabs chipped for market.

2 D - delivered, M - picked up at mill, Dash means none quoted.

published at the request of the sawmill operators. The regional price ranges are listed in Table 4.1.

Most of the slab production on the Island is sold as residential fuelwood which may be purchased full length, blocked, delivered or at the mill. The market for slabs has grown substantially over the past few years and the market value in some areas is high. As an example, one sawmill owner who was considering chipping his slabs for sale a few years ago now receives as much for his slabs at the mill as he would for delivered chips at present prices. The above does not, however, indicate that sawmill owners would not shift from slab production to chip production. Slabs are presently sold to homeowners in small loads with most sales occurring in the fall. The sawmill owner therefore makes many small deliveries at high cost and/or inventories large volumes of slabs for most of the year. A number of the larger sawmill owners expressed interest in selling their full production to a single purchaser and indicated that they would be willing to discount their prices to secure a guaranteed market.

One large sawmill presently chips all its slabs and trim for sale as pulp chips outside the Province. The chip prices for exported pulp chips are presently higher than their market value as fuel for producers with large volumes and suitable equipment. Slab production from two other sawmills is presently chipped to produce fuel for three institutional buildings (see Section 5).

Shavings and sawdust are presently sold for fuel and agricultural applications or disposed of as waste. The fuels are sold separately, mixed, delivered or picked up. At least one

sawmill owner manufactures and sells sawdust burners to provide a steady market for his residues. Shavings and sawdust have very low values in most areas at the present time and are expected to provide the major competition for wood chip fuel; however, the supply of these residues is limited and widely dispersed. Total annual production of sawdust and shavings from larger mills was estimated at 5551 ODt for the Province. Over 65% of the production is presently consumed by agricultural and residential heating applications.

4.2 Sustainable Forest Production

Prince Edward Island contains aproximately 276,000 ha (670,000 acres) of forested land which is virtually all productive. Approximately 10% of the forest land is owned by the Crown with the remaining 90% being owned by approximately 12,000 landowners (16,000 woodlots).

Woodlots average 16 ha (38 acres) in size; however, the area controlled by a single owner ranges from less than 2 ha (4.9 acres) to more than 80 ha (194.4 acres) in one or more parcels. The broad base of ownership and the small area controlled by the Crown limits control over resource management and the scale of operation which can be supported economically in the Province.

The sustainable level of harvest for each region was estimated based on the 1982 inventory by Dendron Resource Surveys Ltd. and the following assumptions:

1) Fifty-five percent of all forest lands will be available for management;

2) Average growth period of 50 years for both hardwood and softwood;

3) Annual sawlog production of 84,000 cu.m (35,000 cords) distributed according to sawmill distribution (Spatial Planning 1982, Forest Resource Development Agreement 1983, Sawmill Owner Interviews).

4) Annual fuel wood production of 240,000 cu.m (100,000 cords) distributed by population at 8.61 cu.m (3.59 cords) per rural household and 1.66 cu.m (0.69 cords) per household in Charlottetown and Summerside. (Resource Ventures Incorporated 1983).

5) Annual production of pulpwood and other products of 48,000 cu.m (20,000 cords) distributed by estimated regional production. (Forest Resource Development Agreement 1984, Contractor Interviews).

6) Approximately 50% of the biomass volume in stands cut using conventional methods is left as recoverable waste.

7) The age-class structure of the future forest will be approximately uniform (normal).

The detailed assumptions and calculations are presented in Appendix 2 and summarized below in Table 4.2. Table 4.2 indicates that there is a sustainable supply of approximately 140,000 ODt of surplus Biomass available on P.E.I. Increased woodlot owner participation, stand growth rates and levels of utilization could increase the surplus significantly.

The majority of the surplus is available in unharvested stands of unmerchantable softwood and hardwood. The softwood surplus is typically in budworm damaged stands which have poor quality wood with limited growth or stands of low average diameter. These stands do not generally have enough sawlog or pulpwood material to support economical harvesting using conventional methods. The hardwood surplus is typically in the poplar working group which has no significant market at the present time. Significant volumes of wood are also found in mixed wood stands which have been high graded for sawlogs or

Table 4.2. Estimated Sustainable Biomass Harvest on P.E.I. by Region.

(Oven Dry Tonnes)

Region	Sustain. Harvest [1]	Present Harvest	Surplus Biomass	Percent Softwood	Conventional Waste Recoverable [2]	Available Biomass
Souris	59736	19354	40381	58%	4401	44782
Montague	94930	46757	48173	47%	11270	59443
Charlottetown	92532	70991	21541	86%	15696	37237
Summerside	60341	52651	7690	100%	11900	19590
O'Leary	44440	26572	17868	49%	6281	24150
Tignish	14300	10485	3815	100%	2265	6080
P.E.I.	366278	226810	139468	62%	51814	191282

1 Gross Biomass Removed

2 Estimated 75% Recoverable

fuelwood leaving a poor quality stand behind. In general, the biomass surplus is in stands with limited or no current commercial value for any products other than chips.

Table 4.2 indicates that an additional 50,000 ODt may be available as residues from conventional logging operations. The residual tops, limbs and unmerchantable wood are currently left in the cutover with most existing operations. Attempts to recover residuals in the cutover have generally resulted in very high chip costs (Savage and O'Hara 1981, Blakeney 1980). With the small, dispersed nature of cutovers on P.E.I., recovery of residues in the cutover can generally be expected to produce high cost fuel. One exception may be where chipping is done in conjunction with a Brush Rake for site preparation.

Wood is forwarded in whole tree form to roadside by a number of contractors. Chips may be produced from this type of operation at moderate cost levels with medium scale, mobile equipment. Creating value for tops and slash while at the same time reducing site preparation costs should result in a shift in production systems to the whole-tree system in the future. Residual biomass would then become an economical source of fuel.

The pulpwood industry on P.E.I. is geared entirely to export because no paper mill exists in the province. Present prices for pulpwood range from $30-37 per ODt ($28-34/cord) at roadside up to $77 per ODt ($70/cord) peeled and delivered to a shipping terminal. At existing prices, pulpwood production could be converted to chip production with similar or greater returns. The shifting of pulpwood operations to whole tree chip production

would increase the Biomass supply by approximately 15,000 ODt and shift approximately 15% of the total existing residual production into chips. The long term attractiveness of the above shift will depend on the value of pulpwood which may increase as forecast shortages are realized in New Brunswick and Nova Scotia.

4.3 Harvesting Systems

The present forest industry on P.E.I. is designed for small scale production from small woodlots. The current structure will be maintained because of the nature of forest ownership. This section summarizes current harvesting systems by type, size and extent of operation.

i) Harvesting Operations

Clearcutting and selective harvest operations provide most of the commercial production of sawlogs, fuelwood and other products. Table 4.3 summarizes the estimated area cut annually for sawlogs and pulpwood. The area cut for fuelwood may be an additional 1600 ha; however, fuelwood is produced from many operations which are not generally classified as harvesting (e.g. removal of dead trees from woodlots). Interviews with contractors indicated that cutover areas averaged 4 ha (range .1-20 ha). Equivalent pulpwood and residual volumes produced, at 30 ODt tonnes per hectare, would be 120 ODt per site (range 3-600 ODt). Many of these sites could provide significant volumes of low cost residue for chipping if whole-tree forwarding methods were used.

ii) Stand Reclamation

Stand reclamation projects are implemented to liquidate low quality stands so that productive plantations can be established.

An estimated 140 hectares were harvested in the softwood and softwood-hardwood cover types in 1984. The softwoods were typically marketed as pulp and the hardwoods as fuelwood. At 60 ODt of low grade wood per hectare, an estimated 8400 ODt of wood suitable for chipping was produced from stand reclamations in 1984. The balance would be hardwood utilized as fuelwood. The area of stand reclamation harvested per year could be increased significantly over the next decade as suitable markets for low grade wood develop.

iii) Commercial Thinning

Commercial thinning operations produce wood for pulpwood and fuelwood. Estimated areas thinned and volumes produced under the Forest Resource Development Agreement in 1984 are summarized in Table 4.4.

Hardwood species from thinnings operations have the highest value as fuelwood. The softwood species are generally marketed as pulp and would have the highest value as chips. Table 4.4 indicates that approximately 2400 ODt of softwood chips could be produced from existing thinning operations. Interviews with silvicultural operators indicate that commercial thinning operations average approximately 3 hectares (range .2-6 ha). Equivalent biomass volumes produced would be approximately 90 ODt per operation (range 6-180 ODt) based on removal of 30 ODt/ha.

The area of commercial thinnings carried out annually could be increased significantly by the development of suitable markets for low grade wood. A shift in production from roundwood to tree-section thinning could also improve biomass utilization.

Table 4.3. Estimated area cutover annually for sawlogs and pulpwood.

	Oven Dry Tonnes		
	Sawlogs	Pulpwood	Total
Annual Production	35,000	15,000	50,000
Estimated Production from Thinning and Stand Reclamation	-	7,000	7,000
Net	35,000	8,000	43,000
Cutover Area @ 60 merchantable tonnes/ha	583	133	717

Table 4.4. Estimated Biomass Volumes from Commercial Thinning Operations

Cover Type	Hectares	Oven Dry Tonnes[1]
Softwood	47	1410
Softwood-Hardwood	34	1020
Hardwood-Softwood	32	960
Hardwood	108	3240
	221	6630

[1] At 30 oven dry tonnes per hectare.

4.4 Summary

In 1984, the major sawmills on P.E.I. produced over 15,000 ODt of slabs, sawdust and shavings. Over 85% of the production was consumed; however, most of the sawdust and shaving consumption provided little or no return to the mill owner. Slabs were marketed at prices much lower than the equivalent market value of chips or fuelwood.

Estimates indicate that 140,000 ODt of surplus biomass and 50,000 ODt of residuals from conventional operations are available annually. An additional 15,000 ODt could be produced by converting existing pulpwood operations to whole tree chipping for a total annual supply of 205,000 ODt. Substantial increases in production could be achieved by improved forest management.

The sustainable supply currently estimated for the Charlottetown and Summerside market areas is significantly lower than the estimated future market (Figure 3.5, 4.2); however, the supply surplus within 50 km of the above centres is greater than the forecast demand. Transportation of chips from the Montague market area to Charlottetown and from O'Leary to Summerside can be expected. Average transportation distances from the forest to the market of 30 km could be expected for the Summerside and Charlottetown markets and 15 km for the smaller market areas.

5.0 Wood Chip Production, 1984

The present wood chip fuel industry on Prince Edward Island consists of four contractors and a number of homeowners who produce their own chip supply. One sawmill produces chips for the pulp market. The chips were not sold as fuel at the time of this report.

The chip production systems and estimated costs are outlined below. Costs are based on the standard costs of labour, equipment rentals and equipment charges outlined in Appendix 3. A markup of 10% is assumed for commercial suppliers to cover overhead and profit. Cost estimates are presented for comparative purposes and may vary substantially with contractors, conditions, and production levels.

5.1 Homeowner-Suppliers

Thirty homeowners operate chip/roundwood furnace combinations as a result of a demonstration project carried out in 1981. The homeowners typically burn a mix of sawdust, roundwood and chips in varying proportions. The homeowners that burn chips as a primary fuel typically produce their annual supply of wood from private woodlots and use a Bruks 722H chipper rented from the Provincial Government through a local contractor. The homeowners harvest their own wood supply of approximately 10 ODt per year and carry out the chipping in one or two days. The equipment used includes chainsaws, a tractor and a truck or trailer which are owned or borrowed by the homeowner. Estimated out-of-pocket costs to produce the 10 ODt annual supply are:

	Total	Per ODt
Fuel for saws	$ 5	$0.50
Fuel for forwarder (Tractor)	20	2.00
Chipper rental	110	11.00
Fuel for chipper	20	2.00
Transportation	20	2.00
Miscellaneous	25	2.50
Total Cost	$200	$20.00

The homeowner considers his equipment to be a sunk cost and may value his labour as a non-taxable fuel saving.

The chip supply was provided by a contractor for the first year of the demonstration. The equipment available for chip production and delivery was inadequate for commercial use and resulted in very high chip costs. Homeowners have since produced their own supply.

Commercial production of wood chips is not expected to compete with the residential homeowner-supplier. A residential market may, however, exist for homeowners who are interested in using chips without the bother of producing their own supply. A similar market currently exists for roundwood.

5.2 Chip Contractor #1

Mr. W. Hemphill was one of the homeowners involved in the demonstration mentioned above and is presently set up for small scale production. He manages an Eeger Beever, a Bruks 722H, a Carthage slab chipper, and an industrial materials handling blower owned by the Provincial Government. He also owns a bulk potato truck modified for residential sawdust and wood chip

delivery.

Mr. Hemphill's involvement in the wood chip industry includes chipping low grade softwood on demand for the Energy from Waste plant in Charlottetown, delivering sawdust and coordinating the rentals of the Province's chippers. Annual production volume is uncertain at the present time.

Chips for the waste plant are produced from low grade pulpwood and cull wood stored near the plant. The chips are produced at the chip plant using the Eeger Beever or the Carthage chipper and blown into containers. The containers are delivered to the plant by an Island Waste Disposal firm. The contractor is also interested in supplying the residential market. The cost of residential chips is estimated based on chipping cull wood purchased at roadside. The wood would be blown directly into a bulk potato truck for delivery. Estimated costs for delivered chips are (See Appendix 3):

	Per OD tonne	
	Waste Plant[1]	Residential[1]
Raw Materials	$30	$30
Delivery	10	-
Chipping	19	21
Delivery	8	20
O/H and Profit	7	8
Total Cost	$74	$79

1 Since various levels of subsidation apply to various components, fair market values were used for calculation.

The contractor is interested in developing the residential market in the area of Charlottetown.

5.3 Chip Contractor #2

The Forestry Co-op in Wellington operates a 400 KW chip plant which has been running since October, 1984. The plant is semi-portable, owned by the Co-op and produces heat in the form of hot water which is sold to a large school. The Co-op rents an old potato warehouse near the school which holds approximately 150 ODt of chips and sawdust. The 24 tonnes of chips produced under this ENFOR project were sold to the Co-op. The remainder of the fuel is a combination of chipped slabs, chipped pulpwood, sawdust and shavings. Slabs and roundwood are purchased and chipped using the Carthage and/or Eeger Beever chipper rented from the Province. The chips are moved into and out of storage using a small front end loader. Delivery to the plant is provided under contract using a truck equipped with two modified, side-dumping fertilizer boxes. Total 1984/85 production is expected to be 375 ODt; however, an undetermined proportion of the mix will be sawdust and shavings. Estimated costs for delivered chips are (See Appendix 3):

	Per OD Tonne	
	Slabs	Pulpwood
Raw Materials	$24	$30
Delivery	-	8
Chipping	25	19
Storage and handling	10	10
Delivery[1]	10	10
O/H and Profit	8	8
Total Cost	$77	$85

1 Screening and delivery to Summerside facility may be additonal.

The Co-op is interested in supplying residential and other medium scale operations from Summerside West.

5.4 Chip Contractor #3

Progressive Wood Products in Iona is expected to supply a 200 KW school in Montague and a 400 KW complex in Charlottetown in 1984/85. The company operates a new sawmill and expects to supply chips produced from slabs. Chips are also being produced from cull softwood when slabs are unavailable. The company rents the Carthage chipper from the Province to chip into 31 cu.m (40 yard) containers which are delivered by an Island waste disposal company. Expected production in 1984/85 is 200 ODt. Estimated costs for delivered chips are (see Appendix 3):

	Per OD Tonne	
	Slabs[1]	Pulpwood
Raw Materials	$10	$30
Delivery	-	8
Chipping	25	19
Delivery	20	20
O/H and Profit	6	9
Total Cost	$61	$86

1 Slabs are assumed to have an opportunity cost of $10/ODt in the contractor's market area.

Photographs of a typical slab shipping configuration are provided in Appendix 3.

The contractor is interested in marketing the annual slab production of the sawmill as fuel chips.

5.5 Chip Contractor #4

J.O. Hornby Ltd. is the only major fuel-chip producer on P.E.I. In 1984/85 the contractor is expected to supply a 1200 KW Hospital in Montague and a 3600 KW Hospital in Charlottetown which is scheduled to begin operation in early 1985. The contractor produces chips from non-commercial harvest operations.

Two general types of operation have been attempted. The first is a "hot" logging operation where wood is cut and forwarded directly to the chipper for chipping into a waiting truck. The second is a cold-deck operation where whole trees are stored in piles (cold-decks) at roadside for later chipping. Cold-decking is also used when the chipper is being repaired or the chipping/delivery system is operating below the capacity of the harvesting/forwarding operation.

The operation includes some combination of a Treelan D-60 chipper owned by the contractor, fellers, a feller buncher, a forwarder, a cable skidder, and two modified dump trucks under contract (3.5 and 5.5 ODt). In 1984, cold-decks were produced using a variety of systems.

Chips are delivered directly to the customer or into an old potato warehouse in Montague, P.E.I. A front end loader is used to move chips into the warehouse and to load the trucks for final delivery. Expected production in 1984/85 is 1800 ODt of which approximately 350 ODt will be delivered directly to the heat plants.

Based on standard operating rates, estimated costs for delivered chips are (see Appendix 3):

	Per OD tonne @ 45 ODt/day	
	Direct Delivery	Through-Storage
Stumpage	$4.00	$4.00
Mechanical Felling	9.00	9.00
Skidding	12.00	12.00
Chipping	9.00	9.00
Trucking[1]	11.00	11.00
Storage and Handling	--	4.00
Delivery[1]	--	6.00
O/H and Profit	5.00	6.00
Total Cost	$50.00	$61.00

1 Storage costs based on a fire-damaged warehouse, trucking costs based on delivery to the Montague Hospital.

Photographs of the operation are provided in Appendix 3.

The above cost estimates are based on achievable average production levels with all equipment in good operating condition. The actual costs of the above operation vary greatly with daily production volume. The operator uses second hand equipment which reduces fixed costs but also results in significant amounts of downtime. The configuration of machinery and trucks also prevents the chipper from operating at full capacity. The above comments should be interpreted with respect to the fact that the contractor has been producing chips for a market which is a small fraction of his capacity. Only limited capital investment can therefore be justified.

The costs of the cold-deck operation are expected to be $6-8/ODt higher than the integrated system because additional equipment is used to pile the cold-decks and to move the chipper with the present configuration. With appropriate equipment such as a forwarder with grapple and a mobile chipper, costs for a cold deck operation should be comparable. The advantages of the cold-deck operation are separation of the harvesting and chipping operations, low cost storage and chip production at lower moisture contents.

The original study of the system was reported in Pratt (1978). The project included 3 Cutters, 2 Skidders, 1 Studwood Processor, 1 Treelan D-60 Chipper, 2 Dump Trucks and a Stake Truck for a 9 day trial. Estimated costs of $42/ODt (1984$) were achieved for delivered chips with the integrated sawlog/chip harvest which produced 250 ODt of chips and 106 cu.m of sawlogs.

5.6 Silvicultural Chip Production

Stand improvement operations such as thinning have been expanding on P.E.I. over the last few years; however, operations involving the removal of softwood and poplar have been limited by the lack of suitable markets. Where softwood can be sold as pulpwood, the value is typically low. Chip production from silvicultural operations may expand the markets for softwood and low grade hardwood in the future. Little information is available on the type of operation mentioned above.

A small demonstration of chip production from a thinning operation was carried out as part of this ENFOR project. The objective was to demonstrate and collect data for a small softwood thinning and tree section trucking operation using available equipment. The thinning site was a 1.2 ha (2.9 ha) block of 30 year old larch (Larix laricina) previously thinned to 2m spacing. The trees were manually cut and bucked into 5 m (16') sections, forwarded to roadside using a tractor and winch and transported in tree sections to a central woodyard using a tandem log truck with loader. The tree sections were then chipped with a small chipper. Approximately 24.1 ODt were produced from the operation. The complete report of the operation is included in Appendix 4.

Recorded costs from the operation and projected costs for future operations were (see Appendix 4):

Per Oven Dry Tonne

	Recorded[1]	Projected
Cutting	$ 22.31	$ 15.00
Forwarding	39.84	27.00
Trucking	12.45	9.00
Sub Total	$ 74.60	$ 51.00
Incentive[2]	22.31	10.00
	$ 52.29	41.00
Chipping	50.00	15.00
Total Cost	$102.29	$ 56.00

1 Based on front thinning operation
2 Cutters paid by the Department of Energy and Forestry

Projected costs are based on a 50% improvement in productivity for the cutting and forwarding operation and a 30% reduction in transportation costs by using a tractor-trailer or truck-trailer combination. Chipping costs were high because the chipper was not suitable for the type of operation carried out. Projected chipping costs are based on a medium to large chipper with grapple loader.

5.7 Summary

Chip production costs on P.E.I. are presently at or above the ceiling prices for all commercial operations except the integrated sawmill operation and the large producer. Present prices do not necessarily reflect the high costs because various types and levels of subsidization exist. When storage and

handling costs are included in the costs of the large producer, his chip costs are increased to within $2 of the ceiling prices. Significant improvements are required to reduce chip costs to attractive levels.

Three of the four chippers presently utilized for processing fuel chips on P.E.I. have production capacities of 11-14 ODt/day under typical operating conditions. These chippers are only suitable for processing material less than 20 cm (8") in diameter with few or no branches. The chipping operation is labour intensive and relatively expensive. The units are best suited for non-commercial applications.

The one commercial chipper on the Island has a potential capacity of 55 ODt/day under typical operating conditions (based on 70% utilization.) Substantial improvements in the harvesting and transportation systems would be required to produce at capacity.

In order to supply the forecast level of demand, significant investment in chipping, harvesting, storage and handling equipment will be required. Significant increases in the productivity of existing systems will be necessary to produce chips at forecast prices.

6.0 Chip Production Systems Outside P.E.I.

A number of chip production systems outside P.E.I. were observed or evaluated based on published reports. This section outlines evaluations of a number of harvesting, chipping, transportation and storage systems used in North America and Scandanavia. Discussion is limited to commercial operations.

Cost estimates are based on standard operating rates presented in Appendix 3. A markup of 10% is assumed to cover overhead and profit. The rates represent estimated costs with P.E.I. labour rates and operating seasons and may not reflect the exact costs of the systems evaluated. Costs from past reports are adjusted to 1984 dollars using the consumer price index.

6.1 Landing Chipper - Chip Van System

The Morbark System based on the Morbark Model 22 Chiparvestor is one of the most common operations in North America. The Morbark chipper is relatively immobile and is therefore set up at a landing and fed by a number of forwarding machines. The system can also be based on other disk chippers such as those manufactured by Nicholson and Treelan with a similar configuration.

One large Morbark System was observed at Nova Scotia Forest Industries in Cape Breton. The stand was a budworm damaged spruce/fir stand felled manually during the winter. Salvageable pulpwood was removed prior to the chipping operation in July.

The components of the system and the estimated capital cost for new equipment were:

Quantity	Unit	Cost
5	Forwarders (rebuilt) with Modified bulk racks	$600,000
1	Morbark Model 22 Chiparvestor	$310,000
5	12.5 ODt chip vans	$575,000
Total Cost		$1,485,000

The forwarders loaded whole trees at the stump area and dumped loads beside the chipper. Chips were blown directly into the vans which were subsequently unloaded at the mill using a large hydraulic truck dump.

Productivity of the system varied with the quality of recovered trees and the downtime of the chipper. Vans required an estimated 3-5 forwarder loads and 25-45 minutes for each load. Daily capacity ranged from 12-15 van loads or 150-190 ODt per eight hour shift. Estimated costs using standard operating rates are listed below for single shift production. Felling costs are estimated. Unloading and handling costs would be extra.

		Per Oven Dry Tonne	
Unit	Hourly-Cost[1]	150 tonnes/day	190 tonnes/day
Stumpage	-	- (Salvage)	-
Felling	-	$6.00	$6.00
Forwarders (5)	$44	11.70	9.30
Chipper	$110	5.90	4.60
Trucks (5)	$45	12.00	9.50
O/H and Profit		3.90	3.20
Total		$39.50	$32.60

[1] See Appendix 3

The system with 5 trucks is suitable for a haul distance of up to 60 kms. Based on 200 productive days per year, the system could produce 30,000-40,000 ODt of chips per year for a capital cost of approximately $1,500,000.

The major difficulty with the system is the complete reliability of the operation on the chipper. When the chipper is not operating, 11 operators and 11 pieces of equipment become unproductive. The chips are also of relatively poor quality for combustion units where uniform chip size is important.

The Morbark and similar systems are used throughout Canada and the United States for processing whole trees into chips. Annual production varies with material processed and number of shifts operated.

Most large Morbark systems operate using a similar configuration. Recent reports and costs adjusted to 1984 dollars and P.E.I. stumpage rates are summarized below. Chisholm and Van Raalte (1980) used a system based on a Koehring Feller-Forwarder and a Chiparvestor to chip mixed-wood blocks in New Brunswick. Chip costs of approximately $26 per ODt were reported before transportation and stumpage. Bowater Newfoundland (1983) used a Chiparvestor with 3 cut and skid crews to harvest residuals from a pulpwood operation. With a 45 km haul, costs of $85/ODt were reported. Costs were projected at $58/ODt for a full scale operation. Wilton and Duffet (1980) reported costs of $52/ODt for small hardwoods, $73/ODt for fire killed softwood and $40/ODt for mature birch stands in Newfoundland. The stands were harvested with a cut and skid operation, chipped with a Chiparvestor and delivered 3-5 kms in modified dump trucks. Estimated costs of

Table 6.1. Summary of reported Costs adjusted to 1984 dollars for large scale chip production projects.

Per Oven Dry Tonne

	Chisholm & Van Raalte	Bowater Newfoundland[1]	Wilton and Duffet Small Hardwood	Wilton and Duffet Softwood Salvage	Wilton and Duffet Mature Birch
Stumpage	$4.00	-	$4.00	-	$4.00
Felling & Forwarding	$12.15	$22.40	$20.60	$27.50	$13.60
Chipping	$9.94	$31.90	$15.80	$19.10	$10.50
Trucking[3]	-	$18.70	$8.50	$10.40	$8.10
Overhead	-	$11.80	$3.40	$16.20	$4.00
TOTAL	$26.09	$84.80	$52.30	$73.20	$40.20
ODt/day (single shift)	95[2]	47	47	39	71

1 Assuming 45% M.C.

2 Estimated

3 Includes Road Building

$50-$77/ODt for salvaging mixed-wood cutovers and $58/ODt for an integrated harvest were reported from similar operations (Wilton 1981, McKinley 1984). The cost breakdown for the above projects is summarized in Table 6.1. Notice that the daily productivity of the operations is well below the capacity of the chipper (200 ODt/day) for all projects.

6.2 The Mobile Chipper-Chip Van System

Mobile chippers mounted on forwarders are typically used for residual chipping operations. The Bruks 1000CT and newer models are used in Eastern Canada for a number of chipping operations. The Bruks units are smaller chippers than the Morbark 22 and can be mounted on either a forwarder or a truck depending on the application. The Bruks system is based on a drum chipper with a chip bin and offers a good method for separating the chipping from the trucking operation.

The Bruks Chip-Van system was observed at Nova Scotia Forest Industries in Cape Breton. The chippers were used to clean slash and unmerchantable wood from a previous pulpwood harvest. The components of the system and the estimated capital costs for equipment were:

Quantity	Unit	Cost
2	Bruks 1000 CT Chippers	$300,000
2	Boogie Axle Forwarders (Rebuilt)	220,000
3	Open Top Chip Trailers	90,000
1	Tractor	90,000
Total Cost		$700,000

The forwarder mounted chipper moved throughout the cutover chipping unmerchantable residue in slash piles into an attached 3.0 ODt bin. When the bin was full, the chipper returned to the trailer parked on-site and dumped its load. Three vans and one tractor were used to deliver the chips in combination with a hydraulic truck dump at the mill.

Productivity of the system varied with the density of residue per hectare and the downtime of the forwarders. The standard chip van required 4-5 bin loads and approximately 4-5 vans were filled per day. Estimated daily capacity ranged from 50-60 ODt per 8 hour shift. Estimated costs of chips at standard operating rates are:

		Per Oven Dry Tonne	
Unit	Hourly Cost	50 tonnes/day	60 tonnes/day
Stumpage, Felling	-	- (Residuals)	-
Chipper (2)	$92	$29.40	$24.50
Trucks (1+3)	65	10.40	8.70
O/H and Profit		4.40	3.70
Total		$44.20	$36.90

Stumpage and felling costs are included in the pulpwood operation; unloading and handling costs would be extra.

The system with one tractor and three trailers is suitable for a haul distance of up to 60 kms. Based on 200 productive days per year, the system could produce 10,000 - 12,000 ODt of chips per year for a capital cost of approximately $700,000. The chipper produced chips of good quality for industrial fuel; however, screening would be required for smaller furnaces.

6.3 The Mobile Chipper-Container System

Chippers such as the Bruks 1000CT chipper with bin are also suitable for use with a container delivery system. A container system was observed at the Boise Cascade operation in Newcastle, New Brunswick. The components of the system and the estimated capital costs for equipment were:

Component	Cost
Chipper mounted on forwarder (rebuilt)	$260,000
Truck, trailer and container system	$135,000
Containers (6)	$ 35,000
Total Cost	$430,000

The chipper was used to process slash piles from a whole tree pulpwood operation. Chips were dumped into the containers for pickup by the self-dumping container truck. The system was operating on a 100 km (1 way) haul with 2 shifts per day. Production was 6 containers per day or an estimated 45 ODt/day. Operations with shorter hauls and more concentrated feedstock could increase productivity to at least 70 ODt/day. Ellingsen (1984) indicated that 95 ODt/day could be produced from full trees chipped at roadside. Estimated costs of chips based on standard operating rates are:

		Per Oven Dry Tonne	
	Rate/Hr	45 ODt/day	70 ODt/day
Stumpage	-	-	-
Felling & Forwarding		(Residuals) -	-
Chipping	$92	$32.70	$21.00
Transport	$57	20.30	13.00
O/H and Profit		5.90	3.80
Total		$58.90	$37.80

[1] Assumes maximum of 70 ODt/day for single truck on long hauls.

Assuming 200 productive days per year and single shift production, the annual capacity of the system observed would range from 5,000 to 6,000 ODt per year for a capital cost of approximately $430,000. Annual production could vary substantially with the material being chipped and the haul distance.

Bowater Newfoundland (1983) used a similar system to chip slash piles but discontinued the project because low bulk densities resulted in very high chip costs. The mobile chipper-container system has been used successfully in Sweden for a number of years to process logging residues (Andersson and Falk 1984).

6.4 Other North American Systems

Most medium and large scale chipping systems in North America use some combination of the configurations outlined above. Equipment and setup may vary.

The Coban Institute (1981) harvested two trembling aspen stands in Alberta and transported the wood whole-tree using pulp trailers to a central Nicholson 22 C.T.U. (chipper). Truck loads averaged 7.6 ODt. The chipper produced approximately 100 ODt/shift for an average chipping cost of $12.90/ODt.

Systems in the United States are similar to those in Canada. Carr (1979) described a successful system at Burlington, Vermont which used 2 feller bunchers, 2 grapple skidders, a Morbark Model 22 Chiparvestor and sufficient chip vans for the haul distance. McKnight (1982) described the system at Boise, Louisiana which used 3 feller bunchers, 6 grapple skidders, 1 Morbark Model 22 Chiparvestor and a Morbark Stacking Conveyor. Chips were piled at the site and later loaded into vans with a knuckleboom clam-bucket loader. Other equipment configurations and systems with smaller equipment are also used in the U.S.

6.5 Scandinavian Systems

Scandinavian systems are generally smaller in scale than most North American systems and may be more suitable for P.E.I. conditions.

Hakkila et al (1978) describes whole-tree softwood thinning operations used in Finland. Table 6.2 summarizes the reported productivity and estimated costs based on similar P.E.I. operating conditions. The productivity estimates are for commercial pine thinnings with strip road spacing ranging from 20-30m for manual felling to 30-50m for mechanized felling. The costs for manual felling with central chipping and chipping at the strip road with a large chipper were comparable. Mechanized

Table 6.2. Estimated Costs Per ODt of Various Thinning Operations Based On Equipment Configurations and Productivity Outlined in Hakkila et al (1978).

System	Est. Rate/Hr	Production Per Hour	Cost Per ODt	System #1	System #2	System #3	System #4
				Manual Thinning Tractor & Winch Forwarding Med. Chipper Chip Van	Feller-Buncher Forwarder Large Chipper Chip Van	Man. Thinning Tractor&Winch Small Chipper Containers	Man. Thinning Boom Buncher Large Chipper Containers
Stumpage				4.00	4.00	4.00	4.00
Harvesting							
Feller & Saw	10.00	1.0-1.9 ODt	5.30-10.00	7.70		7.70	7.70
Small Feller-Buncher	35.00	1.3-2.9	17.20-38.50		16.70		
Bunching at Strip Road							
Tractor & Winch	20.00	2.7-3.0	6.70-7.40	7.10		7.10	
Boom-Type Buncher	40.00	5.3-7.6	5.30-7.50				6.40
Chipping and Transport							
Forwarder (1)	44.00	2.9-3.3	13.30-15.20	15.20	13.30		
Small Strip Road Chipper	35.00	0.8-1.3	26.90-44.00			35.40	
Lg. Strip Road Chipper	92.00	2.9-4.1	21.70-30.70				26.20
Med. Landing Chipper	75.00	4.9-9.1	8.20-15.30	11.70			
Large Landing Chipper	110.00	5.7-12.9	8.50-15.30		11.90		
Trucking Chips (2)				13.90	13.60	13.90	13.90
TOTAL				59.60	59.50	68.10	58.20

(1) 200 m average forwarding distance, forwarder moves 1.7-2.3 Odt/load in 7-8 m sections and has highest productivity in combination with feller-buncher, large chipper moves 3 ODt/load

(2) 50 km average haul, 12 ODt chips per truck, 13.5 ODt per chip van

felling had significantly higher cost than manual felling in thinning operations. Strip road chipping with a small chipper appeared to be uneconomical because the chipper productivity was very low. Balance in the systems is easily achieved because the components can be run independently.

Based on Hakkila et al (1978), a thinning operation with 5 fellers, 2 tractors, 2 forwarders, 1 large landing chipper and 2 chip vans could produce 10,000 ODt/year with an investment of approximately $840,000. An operation with 2 fellers, 1 boom-type buncher, 1 medium strip road chipper and 1 container truck with trailer could produce 4,000 ODt/year with an investment of approximately $500,000. Similar systems can be used for whole-tree harvest with significant improvements in felling and forwarding productivity.

Andersson and Falk (1978) describe whole-tree utilization systems in Sweden. The major systems range from chipping thinnings in small woodlots to large central conversion facilities. The major Swedish systems are designed in one of three configurations:

1. Mobile Chipper - Containers - Transport
2. Forwarding - Landing Chipper - Transport
3. Forwarding - Whole Tree Trucking - Central Processing

All systems can be used for thinning, whole tree or residual harvesting. The first system is generally used for residual removal. Table 6.3 summarizes the reported productivity and estimated costs for whole tree/tree section harvesting based on similar P.E.I. operating conditions. The productivity estimates

Table 6.3. Estimated Costs Per ODt of One Thinning and Three Harvesting Operations Based On Andersson and Falk (1984).

System	Est. Rate/Hr	Production Per Hour	Cost Per ODt	System #1	System #2	System #3	System #4
				Manual Thinning Tractor, Small Chipper & Bin Containers	Feller-Buncher Mobile Chipper Containers	Feller-Buncher Forwarder Large Chipper Containers	Feller-Buncher Forwarder Whole-Tree Transport
Stumpage				4.00	4.00	4.00	4.00
Harvesting							
Feller & Saw	10.00	1.1 ODt	9.10	9.10			
Feller-Buncher	51.00	8.9-11.5	4.40-5.70		5.00	5.00	5.00
Chipping and Transport							
Forwarder (1)	44.00	4.0	15.00			15.00	15.00
Small Mobile Chipper	35.00	0.9	38.90	38.90			
Large Mobile Chipper (1)	92.00	4.5	20.40		20.40		
Large Landing Chipper	92.00	8.0	11.50			11.50	
Trucking Chips (2)	57.00		13.90	13.90	13.90	13.90	
Trucking Whole-Trees (2)	50.00		15.90				15.90
TOTAL				65.90	43.30	49.40	39.90
							(Unprocessed)

(1) 200 m average forwarding distance
(2) 50 km average haul, 12 ODt chips and 10.5 ODt tree sections per load

are for stands which are predominantly softwood. The costs for the three harvesting methods are comparable when processing costs are added to whole-tree transport. Strip road chipping of thinnings has high cost due to the low productivity of the small chipper utilized.

Based on Andersson and Falk (1984), a tree section harvesting operation with 2 fellers, 1 medium mobile chipper and 1 container truck with trailer could produce 4000 ODt/yr with an investment of approximately $410,000. An operation with an investment of approximately $770,000 (1 feller-buncher, 2 forwarders, 1 medium landing-chipper and 1 container truck with trailer) could produce 9000 ODt/yr. An operation with an investment of approximately $520,000 excluding chipping equipment (1 feller buncher, 2 forwarders and 1 whole-tree truck) could produce 10,000 ODt/yr.

A number of Scandanavian systems may be suitable for harvesting softwoods under P.E.I. conditions. The systems using a truck-mounted landing chipper in conjunction with a container system and tree-section trucking appear to be the most promising for Island softwood operations.

6.6 Small Scale Systems

Small scale production of chips exists in all the countries mentioned above. The systems are generally built around small chippers powered by tractor PTO shafts. The operator generally processes chips for his own use with a chipper which is either owned, borrowed or rented.

The harvesting system can involve felling dead wood, thinning, clearcutting or cleaning up residuals from conventional operations. The wood is typically forwarded using tractors or small skidders to a trail or road where it is fed manually to the chipper.

Overall productivity of small scale systems is low and chip costs are high (Savage and O'Hara 1981, Furuseth et al 1981, Schnieder 1984). Note that in the previous section, the costs of chips produced using small chippers were considerably higher than the ceiling price for chips. The systems are generally only economical if the operator burns his own chips and does not consider his labour and equipment costs to be relevant. For the purposes of this report, small scale systems are not expected to be commercially viable; however, they may still account for significant levels of chip production for small users.

6.7 Summary

Many different chipping systems exist in North America and Scandanavia. A number of the systems are designed for very high volume production and long haul distances which are not required on P.E.I. The systems which appear to be the most promising include conventional whole-tree harvesting and forwarding for limby hardwoods and tree section felling and forwarding for softwoods. Tree section hauling may be economical for building inventories of softwood species.

Estimated and reported costs for delivered chips from medium to large scale systems range from $40 to $84/ODt. The lowest

costs are achieved by very large scale systems which are not suitable for P.E.I. conditions; however, costs of less than $50/ODt are achievable for whole-tree chips delivered directly to the consumer. The costs of chips from thinning operations will be higher; however, the thinning costs may be subsidized.

Small scale systems generally result in high chip costs and are not competitive for commercial chip production unless costs are subsidized. The systems are suitable primarily for chip burners supplying their own chips.

7.0 Chip Production Systems Components

In this section, the components of the chip production systems including the alternative methods and relative costs will be discussed. Analysis is limited to the chipping and transport of forest products; discussion of a sawmill residue system is included in Section 8.

The wood chip production system is made up of six major components:

1. Harvesting
2. Primary Transport (e.g. forwarding)
3. Chipping
4. Secondary Transport (e.g. trucking)
5. Storage, Processing and Handling
6. Delivery

One or more components may be eliminated in some production systems. For example, chips could be delivered directly to the customer's fuel bin.

Comparative costs are based on standard operating rates presented in Appendix 3. The rates are based on:

1. 200 operating days per year
2. single shift production.

Standard costs are used for consistent comparison and may be higher or lower than actual rates depending on the skills and scale of the contractor. The standard costs for machines include

a 30% return on equity, before tax for capital invested in equipment which is expected to be adequate for the level of risk involved.

7.1 Harvesting and Forwarding Systems

Practical harvesting systems for chip production on P.E.I. include:

1. Whole tree harvesting for chip, sawlog and fuelwood production.
2. Chipping of low quality wood from commercial thinning operations.
3. Processing of residuals from conventional operations.

Equipment utilized could include chainsaw crews, feller bunchers, tractors, skidders and forwarders. The three basic systems are described below. Comparative costs are outlined in Table 7.1.

i) Whole-Tree Harvesting

Whole-tree harvesting is the most productive method of harvesting for chip production because of high productivity in cutting, forwarding and chipping. Where forwarders are used, large trees must be cut into sections. Whole-tree harvesting can be done using three major methods: integrated chipping, cold-decking and separate felling.

Integrated chipping systems require that the production of the harvesting, forwarding, chipping and trucking system be well balanced. The system can use cut and skid crews, a feller buncher and a grapple skidder or forwarder or other equipment configurations easily. A forwarder should be preferred when

available to prevent excess knife wear on the chipper from soil in the biomass. Under this system the wood is easy to chip because it is relatively moist, trees are easy to process because they have not become entangled and double handling of wood is minimized. The major disadvantages involve breakdowns and scheduling. A breakdown in any piece of equipment, especially the chipper will affect the productivity of the entire system. Tight scheduling of forwarders, chippers and trucks is required to keep the system operating efficiently. Therefore, the system works well for stand reclamation, harvesting poplar and harvesting other non-commercial stands.

Cold-decking separates the harvesting operation from the processing operation. Wood is cut and forwarded to piles or cold-decks for later chipping. The system is most productive if a forwarder is used which can forward the wood and pile the cold-decks. The advantages of the system are: harvesting can be accomplished without coordinating the chipping and trucking operation; wood can be inventoried at roadside at low cost and drier chips can be produced. The disadvantages involve double handling which occurs because whole trees must be piled and later removed from the entangled piles for chipping; drier wood which is more difficult to chip; and chipper mobility which is required for efficient operation.

Cold-decking can work well for whole-tree sawlog and fuelwood operations, thinning operations and small harvest operations where integrated chipping is not practical. The addition of value to low grade wood could encourage sawlog and fuelwood contractors to forward all the wood from an operation to

a central landing for later processing. A number of operators already carry out complete clearcuts to satisfy landowners. Cold-decking residuals for chipping could improve returns and reduce site preparation costs. Cold-decking could also work well for thinning operations (discussed below) and where landowners want to improve or clear their forests on a small scale. Wood could be piled and later sold to a chip contractor.

Separate felling can be used in advance of forwarding to increase natural drying or in combination with a mobile chipper operation. Advance felling has been used in Sweden to reduce moisture contents (Andersson 1984). North American experience is limited.

ii) Thinning Operations

Commercial thinning operations on P.E.I. are typically concentrated in hardwood stands where the wood has high value as firewood. Development of the wood chip market could improve the returns on softwood and low-grade hardwood thinning operations. Biomass thinning could be done using two major methods: chipping on the strip roads or forwarding tree sections to roadside for chipping, cold-decking or transport.

Strip road chipping requires a mobile chipper and container. A suitable system could include a tractor, trailer mounted chipper and bin combined with a container delivery system. For high volume commercial chipping, a medium tractor or forwarder with grapple loader are recommended for chipper transport. Manually fed units are generally uneconomical (see Section 7.2). Strip road chipping reduces double handling of the wood but also

reduces the productivity of the system because the same unit is used for chipping and forwarding. Adding a chip forwarder doubles the capital tied up in a system with limited productivity. See section 7.2 and 7.4 for further discussion.

Forwarding tree sections to roadside offers a practical alternative for thinning operations. This can be done using tractors, skidders or forwarders. Forwarders with telescopic booms and extended racks can be the most productive equipment for this type of operation (Hakkila et al 1978, Andersson and Falk 1984). The system requires double handling of the tree sections by the forwarder and the chipper but effectively separates the chipping and forwarding systems.

iii) Residential Salvage

Tops and branches from convential operations are a final source of raw materials for chips. Tops and branches dispersed throughout the cutover area can result in high cost chips (Blakeney 1980, Savage and O'Hara 1981). Conversion of conventional sawlog and fuelwood systems to whole tree forwarding would be a more practical method of utilizing slash on P.E.I. The conventional waste then becomes part of the cold-deck and is processed accordingly.

(iv) Wood Costs

Many studies have been done to determine the cost of producing wood at roadside. Costs estimates vary substantially. Table 7.1 outlines typical costs which could be expected for whole trees or tree sections at roadside based on discussions with contractors and the studies cited.

Table 7.1. Estimated Costs of Wood At Roadside Under P.E.I. Conditions

Whole-Tree Clearcut

System	Rate/Hr	System#1 2 fellers med. skidder	System#2 feller-bunch. 2 grap. skid.	System#3 feller-bunch. 2 forwarders
Daily Production ODt		30	60	60
		Cost/ODt		
Stumpage		4.00	4.00	4.00
Cutter & Saw	10.00	5.33		
Fell.-Bunch.	51.00		6.80	6.80
Med. Skidder	35.00	9.33		
Gr. Skidder	39.00		10.40	
Forwarder	44.00			11.73
Overhead & Profit		4.00	4.00	4.00
TOTAL		22.67	25.20	26.53

Tree Section Thinning

	Rate/Hr	System#1 2 fellers tractor&winch to strip road	System#2 1 feller tractor&winch to roadside	System#3 2.5 fellers tractor&winch forwarder
Daily Production ODt		18	8	24
		Cost/ODt		
Cutter & Saw	10.00	8.89	10.00	8.33
Tractor	20.00	8.89	20.00	6.67
Forwarder	44.00			14.67
Overhead & Profit		2.00	4.00	4.00
Total		19.78	34.00	33.67
Incentive		10.00	10.00	10.00
TOTAL		9.78	24.00	23.67

Sources: Appendix 4, Pratt 1978, Damman and Andrews 1979,Hakkila et al 1978, Andersson and Falk 1984.

The costs used in this report are $10/ODt ($4.50/green ton) for felled wood and $21.00/ODt ($9.50/green ton) for wood delivered to roadside as part of an integrated operation. The respective costs are $12/ODt ($5.50/green ton) and $25/ODt ($11.50/green ton) for purchased wood. The cost is assumed to be the same for cold-decks as for feeding directly to a chipper. For comparison, the price of limbed, bucked and piled pulpwood was approximately $35/ODt ($32/cord) at roadside in 1984.

Silvicultural subsidies and stumpage reductions may apply for wood harvested from salvage operations; however, productivity would also be lower. The subsidies have not been considered in calculating average wood costs from harvest operations because salvage operations are expected to decrease in significance in the long run as poor quality stands are liquidated.

7.2 Chippers

For the purposes of the following analysis, chippers are classified into four general categories:

1. Small: $10,000 - $30,000, 1.5 - 3 ODt/hr
2. Medium: $50,000 - $100,000, 4-8 ODt/hr
3. Large: $100,000 - $200,000, 9-15 ODt/hr
4. Very Large: greater than $250,000, 15 ODt/hr

Category 1 chippers are generally too small for practical commercial use. These units are limited to small operators who may supply a small market as part of their overall operations. Category 2 chippers can be appropriate for the medium sized contractor who wants to produce chips in conjunction with his

operation. One example would be a silvicultural contractor. Category 3 chippers are suitable for a full time contractor whose primary business is producing wood chips. Category 4 chippers are generally too large for P.E.I. conditions and, therefore, will not be discussed. A unit such as the Morbark Model 22 Chiparvestor could chip 30,000 ODt/yr and would process an average 4-6 ha biomass cutover in 2-3 days. Access to many woodlots would be impractical. The unit would be expected to spend most of the time unproductive or being transported.

The design of the wood chip production system is determined primarily by the stage where the chipping takes place. Chipping may be done at three general locations:

1. The stump area
2. The strip road
3. Roadside
4. Central Chip Terminal

The location of the chipping determines the type of equipment used, the productivity of the system and cost. Comparative costs are outlined in Table 7.2.

The comparative cost analysis is based on the following major assumptions:

1. Production and costs estimates outlined in Appendix 3.
2. Utilization of 75% for mobile chippers, approximately half of which is spent chipping and the remainder transporting and handling chips. Small chippers have very high setup times because they are fed manually by the operator who must slow down the chipper and return to the cab each time the unit is moved.

Table 7.2. Comparative Analysis of Different Chipping Systems Using Standard Costs.

	Thinning Operation			Stump Area Chipping			Roadside Chipping		
	System#1	System#2	System#3	System#4	System#5	System#6	System#7	System#8	System#9
System	sm. chipper tractor 1.5 ODt bin containers	md. chipper tractor 2.5 ODt bin containers	lg. chipper forwarder 3.0 ODt bin containers	sm. chipper tractor 1.5 ODt bin containers	md. chipper tractor 2.5 ODt bin containers	lg. chipper forwarder 3.0 ODt bin containers	one driver-operator md. chipper trailer dump truck	md. chipper on truck contain. or lg. trucks	lg. chipper on truck contain. or lg. trucks
Chipper									
Location	strip road	strip road	strip road	cutover	cutover	cutover	roadside	roadside	roadside
Production (ODt/hr)	3	6	12	3	6	12	6	8	12
Utilization	75%	75%	75%	75%	75%	75%	50%	70%	70%
Setup & Dumping(min)	25	15	12	20	12	10	15	10	10
Bin/Truck Size (ODt)	1.5	2.5	3.0	1.5	2.5	3.0	3.5	12.0	12.0
Avg. Forw. Dist. (m)	200	200	200	200	200	200	0	0	0
Avg. Speed (m/min.)	40	40	50	50	50	60	0	0	0
Annual Prod. Shifts (8 hours)	200	200	200	200	200	200	200	200	200
Minutes per Load	87	67	47	77	60	42	100	143	100
ODt/hr	1.0	2.3	3.9	1.2	2.5	4.3	2.1	5.0	7.2
Cost/hr.	32.00	55.00	92.00	32.00	55.00	92.00	35.00	65.00	78.00
Cost/Odt	30.81	24.44	23.85	27.50	22.00	21.58	16.67	12.90	10.83
Annual Prod. (ODt)	1662	3600	6171	1862	4000	6821	3360	8064	11520

3. Utilization of 70% for roadside chippers, all of which is spent chipping. A net utilization of 50% is assumed for System #7 because the operator shuts down the chipper while he delivers the truckload of chips.
4. Forwarding speeds are lowest in thinning operations where tighter maneuvering is required.

The major results are discussed below.

i) Stump Area Chipping

Chipping at the stump area is generally used for processing waste from conventional logging operations for fuel (Andersson and Falk 1984). Where these residues are to be chipped in the small cutovers found on P.E.I., concentrating the residues at the landing during the conventional operation is preferred.

Chipping whole trees at the stump and forwarding chips to containers may be a viable alternative for production. Forwarding to detachable trailers or trucks could also be used; however, costs would be higher. Table 7.2 indicates that stump area chipping is more than 60% more costly than roadside chipping; however, the elimination of a tree-section forwarder or skidder may compensate for the higher costs. The addition of a chip forwarder to the system could increase productivity significantly for long forwarding distances (see Section 7.4). Stump area chipping can provide the cleanest chips and is most productive in conjunction with a feller-buncher. The major disadvantage is the high capital cost for equipment with limited flexibility. Stump area chippers must also be floated distances more than a few kilometers.

Chipping costs from an efficiently run operation range from approximately $22/ODt for a large chipper to $27/ODt for a small, manually fed chipper. The above includes the cost of forwarding which is performed by the chipper.

ii) Strip Road Chipping

Mobile chippers can also be used effectively for strip road chipping in thinning operations. For efficient operation, the wood should be bunched at the strip road manually or using a winch. Chipper productivity is reduced because more setups are required and tight maneuvering reduces forwarding speeds.

Chipping costs ranging from approximately $24/ODt for a large chipper to $30/ODt for a small, manually fed unit could be expected from an efficiently run operation. The above costs include the cost of forwarding which is performed by the chipper.

iii) Roadside Chipping

Roadside chipping with truck mounted units offers the most flexible system for chipping in P.E.I. conditions. The units could be used for chipping in an integrated system, chipping cold-decks or processing at a centrallized wood yard. The most flexible system would be made up of:

1. Tandem Truck
2. Chipping Unit and Motor
3. Grapple Loader with Enclosed Cab
4. Chip Bin

The chip bin combined with a rotating chute could be used for chipping while trucks are moving or in combination with a container delivery system; however, the bin is not required for

efficient operation of the system.

Roadside chippers mounted on separate trailers can produce chips at lower cost per productive hour than truck mounted chippers; however, equipment flexibility is limited. For example, frequent shutdowns will be required to move the chipper while chipping cold-decks. Truck mounted chippers can also be easily transported to a power source or garage for easier winter operation.

Chip costs ranging from approximately $11/ODt for a large chipper to $18/ODt for a medium chipper and truck combination run by one operator could be expected from an efficiently run operation.

iii) Centralized Chipping

Centralized chipping using a large, stationary chipper provides the most economical system for chipping because the chipping operation is independent from the harvesting and transportation systems, inventory can be stored outside as whole trees and chipper maintenance is simplified. Transportation and double handling costs may, however, be high. Specially designed transportation vehicles are necessary to overcome the first problem. Double handling cannot be avoided. Centralized chipping is difficult to evaluate in isolation of the overall transportation and storage system. See section 8.5 for a complete analysis.

7.3 Transportation

The transportation system is defined by the type of material handled and the vehicle used. Four major types of transportation systems are practical on P.E.I.:

1. Self-unloading trucks, dump trucks, dump trailers
2. Self-unloading vans
3. Container trucks
4. Whole tree trailers

Regular chip vans are not considered to be practical because unloading facilities are required.

The comparative costs of chip tansportation and tree-section transportation are outlined in Table 7.3 and 7.4 respectively. The analysis is based on the calculations in Appendix 3 and the following assumptions:

1. Chip densities of 145 OD kg/cu.m (9 OD lbs/cu.ft.) in the delivery vehicle.
2. Chipper utilization of 70% and truck utilization of 90%.
3. Softwood tree-section densities of 120 OD Kg/cu.m (7.5 OD lbs/cu.ft.) in delivery vehicle. For comparison, Lavoie (1980) achieved densities of approximately 190 OD kg/cu.m (12 OD lbs/cu.ft) for fir and 135 OD Kg/cu.m (8.4 OD lb/cu.ft) for spruce in a whole-tree trucking operation. Densities of 120 OD kg/cu.m (7.5 OD lb/cu.ft) were achieved in this ENFOR project (see Appendix 4). The Coban institute (1981) achieved densities averaging 85 OD Kg/cu.m (5.3 OD lb/cu.ft) hauling poplar whole-tree.

The major results are discussed below.

i) Conventional Trucks

Self unloading trucks such as potato trucks and side dumping fertilizer trucks are readily available on P.E.I. with volumes ranging from 3-4.5 ODt. Bulk potato trucks are suitable for chip delivery; however, the operator must work with the chips to keep them "flowing". A modified side dumping lime truck is presently being used to deliver wood chips and mill residues to the semi-mobile chip furnace operated by La Cooperative Forestiere. Dump trucks and trailers which can be modified to carry 3-8 ODt of chips are also readily available on P.E.I. Tandem dump trucks are suitable for distances up to 30 km. Dump trailers should be used for longer distances. Both types of units can result in costs greater than $20/ODt for haul distances greater than 40 km.

ii) Self-Unloading Vans

Self-unloading chip vans can be suitable for large volume deliveries from the harvesting operation to central storage or larger customers. Two types of self-unloading vans are available. The first is a live bottom system unloaded by crossbars moved mechanically by two or three chains. The second system has a floor made up of sliding slats driven hydraulically in a cycle which unloads the van. Sliding floor vans have high initial cost but generally have lower maintenance costs.

Self unloading vans are comparable in cost to dump trucks for distances of up to 20-30 km. Beyond 30 km, the cost advantage of live bottom vans increases with distance. For 50-60 km hauls, live bottom vans are approximately 25% less costly than dump trailers. Transport costs of $12-14/ODt can be expected for 40-50 km hauls in combination with a medium or large chipper.

One disadvantage of the chip van system is that the size of the vehicle and difficulty in maneuvering can limit access to many small and medium sized Island woodlots. Self-unloading vans are only expected to be economical for long distance transport of large volumes of chips from an integrated chipping (or storage) operation. System flexibility is limited.

iii) Container Trucks

Container trucks typically used for garbage disposal are also available. The container system offers a practical method for separating the chipping and transportation system and for keeping the chip truck fully productive. The conventional containers currently used are limited to approximately 4.2 ODt per load. These trucks have costs comparable to dump trucks.

A larger-volume container-truck designed for chip transport is currently being used in New Brunswick. The system includes a trailer for carrying a second bin and a container system that enables the driver to handle containers without leaving the cab. The unit with two bins holds an estimated 12 ODt.

Container trucks are the most efficient transportation system for low volume chip production because the chipping is effectively separated from the trucking operation. The container system is more efficient than dump trucks for hauls over 20 kms. The container system results in higher transport costs than chip vans where large chippers are used for long hauls; however, the increased flexibility of the container system is expected to outweigh the marginal cost disadvantage.

Table 7.3. Relative Trucking Cost Estimates For Chips Based on Standard Rates.

Avg. Haul Speed(km/hr)	60	Annual Prod. Shifts	200
Hours per Shift	8	Chipper Utilization	70%

	Small Dump Trucks	Dump Trailers	Live Bot. Chip Vans	Cont. Truck & Trailer
Truck Volume (Odt)	3.5	7	13.5	12
Hourly Rate	31	45	52	57
Availability	90%	90%	90%	90%
One Way Haul(km)		Trucking Cost/ODt		
Chipper Production(Odt/hr)	6	Annual Production(ODt)		6720
5	7.38	9.64	10.27	6.73
10	8.86	10.71	10.91	7.52
20	11.81	12.86	12.20	9.10
30	14.76	15.00	13.48	10.69
40	17.71	17.14	14.77	12.27
50	20.67	19.29	16.05	13.85
60	23.62	21.43	17.33	15.44
Chipper Production(Odt/hr)	8	Annual Production(ODt)		8960
5	6.09	7.77	8.10	6.73
10	7.57	8.84	8.75	7.52
20	10.52	10.98	10.03	9.10
30	13.47	13.13	11.31	10.69
40	16.42	15.27	12.60	12.27
50	19.38	17.41	13.88	13.85
60	22.33	19.55	15.17	15.44
Chipper Production(Odt/hr)	12	Annual Production(ODt)		13440
5	4.80	7.50	7.80	6.73
10	6.27	8.57	8.44	7.52
20	9.23	10.71	9.72	9.10
30	12.18	12.86	11.01	10.69
40	15.13	15.00	12.29	12.27
50	18.08	17.14	13.57	13.85
60	21.04	19.29	14.86	15.44

See Appendix 3 for assumptions and calculations.

With the container system high volumes can be transported while only a medium sized truck is required to access the cutover. Bins can also be left on-site for low volume and mobile chipper operations. The multiple container system requires a turnaround site near the chipping area where the driver can unhitch the trailer and unload one container. A side loading unit is available which eliminates the need for unhitching; however, capital and maintenance costs are very high.

Costs ranging from approximately $10/ODt for a 30 km haul to $15/ODt for a 60 km haul can be expected for the container system. Container systems are the most practical transportation systems for low volume production in P.E.I. conditions.

iv) Tree-Section Trucking

Whole-tree and tree-section trucking can be used for moving trees to a central area for storage or chipping. The system is recommended primarily for softwood species from thinning and harvesting operations. Transportation efficiencies with limby hardwood trees are poor and are assumed to be uneconomical (The Coban Institute 1981).

Suitable delivery vehicles range from conventional 6 m (20 ft.) log trucks to large trucks with trailers. The vehicles should be equipped with sides to eliminate the need for trimming and for safe transport on public roads. For P.E.I. conditions, the trucks should also be equipped with loaders which are centre-mounted on larger vehicles. Tree-section handling is recommended over whole-tree handling because forwarding and handling are generally more efficient. Both will be referred to as tree-

section trucking in the following dicussion.

A major issue in tree-section trucking is whether or not to compact the load. Hakkila et al (1978) reported that alternating butts and tops in whole tree loads can increase loads by 20%. Trucks with hydraulically driven stakes which tilt outwards 30° during loading can increase loads by 56%. The additional cost and weight of the hydraulic system and the load densities were not stated. Wellwood (1979) reported that a truck with winches could compact loads by 20% from 75-100 OD kg/m^3 to 90-120 Kg/m^3 (assuming 50% M.C.). Wellwood also stated that Swedish experience indicates that uncompacted whole-trees are economical for hauls up to 30 kms while compaction or chip hauling should be used for longer hauls. Larsson (1981) outlined typical load densities in Sweden of 84 OD Kg/m^3 for slash and 121 OD Kg/m^3 for uncompacted tree sections (assuming 40% M.C. for slash and 45% M.C.. for tree sections). Andersson and Falk (1984) indicated that compaction in Sweden is effective primarily for trucking residuals and for hauls longer than 50 kms.

In this report, whole-tree and tree-section transportation costs are based on uncompacted loads at densities of 120 OD Kg/m^3 for softwood species. Mechanically compacted loads are not expected to be advantageous for the short hauls on P.E.I. Natural compaction by loading heavy materials on top or simple compaction using winches is assumed to be sufficient to generate the above density. Additional compaction equipment will increase the capital cost, operating cost and gross vehicle weight of the truck and is expected to result in little or no savings. For

further discussion see Appendix 4.

Table 7.4 outlines typical transportation costs for tree-section hauling. For P.E.I. conditions, a 15 m (50 ft.) modified pulp trailer offers a good combination of cost and flexibility for tree-section transport. Tree-section transport is expected to be $2-3/ODt more costly than chip transportation; however, chipping and storage costs will be reduced. The transportation system must be evaluated in conjunction with the entire supply system. See Section 8 for further discussion.

7.4 Chipping-Transportation Systems

The entire chip-transportation system must be evaluated for accurate comparison of costs. Table 7.5 and 7.6 outline the comparative costs of alternative chipping-transportation systems based on typical P.E.I. conditions and the analysis in sections 7.1-7.3.

Table 7.5 outlines comparative costs for efficiently run operations which may be suitable for small contractors. For small to medium scale production, the analysis indicates that inwoods chipping operations in combination with a container delivery system are the most economical. The medium chipper produces the lowest cost chips at approximately $47/ODt delivered. The cost per tonne of the chipper is relatively high; however, the unit acts as both the chipper and the forwarder.

Table 7.4. Relative Trucking Cost Estimates For Tree Sections Based on Standard Rates.

Avg. Haul Speed(km/hr)	60	Annual Prod. Shifts	200
Hours per Shift	8		

	Log Truck	Tractor Trailer	Truck & Trailer
Truck Volume (Odt)	4.5	10.5	13.5
Hourly Rate	42	50	56
Utilization	90%	90%	90%
Loading Time	25	45	60
Unloading Time	15	35	45
One Way Haul(km)	Trucking Cost/ODt		
5			
Round Trip Time (min.)	56	100	128
Cost per Tonne	8.64	7.94	8.83
Annual Capacity (ODt)	7776	10080	10143
10			
Round Trip Time (min.)	67	111	139
Cost per Tonne	10.37	8.82	9.60
Annual Capacity (ODt)	6480	9072	9331
20			
Round Trip Time (min.)	89	133	161
Cost per Tonne	13.83	10.58	11.14
Annual Capacity (ODt)	4860	7560	8044
30			
Round Trip Time (min.)	111	156	183
Cost per Tonne	17.28	12.35	12.67
Annual Capacity (ODt)	3888	6480	7069
40			
Round Trip Time (min.)	133	178	206
Cost per Tonne	20.74	14.11	14.21
Annual Capacity (ODt)	3240	5670	6305
50			
Round Trip Time (min.)	156	200	228
Cost per Tonne	24.20	15.87	15.75
Annual Capacity (ODt)	2777	5040	5690
60			
Round Trip Time (min.)	178	222	250
Cost per Tonne	27.65	17.64	17.48
Annual Capacity (ODt)	2187	4082	4666

Figure 7.5. Comparative Analysis of Four Major Harvesting-Delivery Systems Using Standard Operating Rates, 200 Metre Average Forwarding Distance and 30 Km Haul.

	System#1	System#2	System#3	System#4
System	small mobile chip. containers	medium mobile chip. containers	medium mobile chip. chip forw. containers	forwarder medium road. chip. dump trail.
Chipper				
Rate/hr	32.00	55.00	55.00	65.00
Production (ODt/hr)	3	6	6	8
Utilization	75%	75%	75%	70%
ODt/load	1.5	2.5	2.5	7.0
Minutes/load	77	60	45	89
Forwarder				
Rate/hr			50.00	42.00
Utilization			75%	75%
ODt/load			2.5	2.0
Minutes/load			45	32
Trucking				
Rate/hr	57.00	57.00	57.00	50.00
Utilization	90%	90%	90%	90%
ODt/load	12	12	12	7
Minutes/load	185	185	185	162
Comparative Cost	Per Oven Dry Tonne			
Stumpage	4.00	4.00	4.00	4.00
Felling	6.00	6.00	6.00	6.00
Wood Forwarding				11.00
Chipping (Forw.)	28.00	22.00	17.00	14.00
Chip Forwarding			15.00	
Trucking	11.00	11.00	11.00	13.00
TOTAL	49.00	43.00	53.00	48.00
Annual Product.(ODt)	1900	4000	5300	4200

. Figure 7.6. Comparative Analysis of Four Major Harvesting-Delivery Systems Using Standard Operating Rates, 200 Metre Average Forwarding Distance and 30 Km Haul.

System	System#1 mobile chip. containers	System#2 mobile chip. chip forw. containers	System#3 forwarder road. chip. chip vans	System#4 forwarder whole tree trucking
Large Chipper				
Rate/hr	92.00	92.00	78.00	
Production (ODt/hr)	12	12	12	
Utilization	75%	75%	70%	
ODt/load	3.0	3.0	13.5	
Minutes/load	42	26	100	
Forwarder				
Rate/hr		50.00	42.00	42.00
Utilization		75%	75%	75%
ODt/load		3.0	2.0	2.0
Minutes/load		26	32	32
Trucking				
Rate/hr	57.00	57.00	52.00	50.00
Utilization	0.9	0.9	0.9	0.9
ODt/load	12	12	13.5	10.5
Minutes/load	185	185	164	178
Comparative Cost	Per Oven Dry Tonne			
Stumpage	4.00	4.00	4.00	4.00
Felling	6.00	6.00	6.00	6.00
Wood Forwarding			11.00	11.00
Chipping	22.00	13.00	10.00	
Chip Forwarding		7.00		
Trucking	11.00	11.00	11.00	13.00
TOTAL	43.00	41.00	42.00	34.00
Annual Product.(ODt)	6900	11000	13000	(Unprocessed) 6000

The use of a small, manually fed chipper increases costs approximately $6/ODt. The addition of a chip forwarder to the system increases the cost significantly because the low productivity of the chipper results in excess forwarder capacity. The forwarder may become economical for very long forwarding distances (i.e. greater than 500 m average distance). These, however, are not common on P.E.I.

A system based on a forwarder, medium roadside chipper and dump trailers can be expected to increase chip costs to approximately $48/ODt. The cost of roadside chipping could be reduced approximately $3-4/ODt by using a container delivery system. This would result in costs of $44-45/ODt for delivered chips which are similar to costs for mobile chipping.

Based on the above analysis, chip costs of $43-48/ODt could be expected from a medium scale operation with a 30 km average haul. Assuming that silvicultural incentives result in comparable costs for wood to the chipper, costs would be $3-4/ODt higher for extraction from a thinning operation. (Refer to Table 7.2).

Table 7.6 outlines comparative costs for efficiently run large scale chip production systems. For typical conditions on P.E.I., the three chip production systems produce chips at comparable cost. The average forwarding distance of 200 m is approximately the breakeven point for the addition of a chip forwarder. The forwarder would reduce costs for longer average distances; however, these are not common on P.E.I. Forwarding tree-sections to roadside for chipping in conjunction with a chip

van produces the lowest cost chips by a small margin. Based on the above analysis, chip costs of $41-43/ODt could be expected from a large scale operation with a 30 km average haul.

Table 7.6 also indicates that tree sections could be trucked to storage at a cost of $33-35/ODt before processing. The result is a margin of $7-8 plus the savings resulting from outside storage to cover the costs of handling and chipping the wood. Tree-section trucking is only expected to be economical in conjunction with a high volume wood processing terminal. The system may also be used for supplementing the covered storage of a small supplier; however, the total chip costs are expected to be comparable to chips inventoried under covered storage. See Section 8 for further analysis.

7.5 Drying, Storage, Handling and Delivery

The cost of producing chips for heating purposes cannot be analyzed in isolation of the storage and delivery system. Although chips which must be inventoried before final delivery will have higher cost they will have a higher fuel value. The above components are analyzed below.

i) Drying

Drying of the chip fuel can be done at three basic locations: the stump, storage and the boiler. Drying at the boiler is of limited interest to the chip producer whose role ends when chips are delivered to the fuel bin.

Cutting a few weeks or months before chipping (sour-felling in Sweden) can be an economical way to dry chips. Patterson and Post (1980) reported a M.C. drop from 37% to 32% in white birch

and 42% to 41% in red oak for trees felled in late spring and left in the cutover for 4 weeks in Massachusetts. Other studies in the southern United States reported drying from 53% to 41% M.C. for pine seasoned 2 weeks in August, from 49% to 30% M.C. for pine seasoned for 4 months from November to February and from 49% to 46% for softwoods seasoned for 2 weeks (McMinn and Taras 1982, Rogers 1981, Garrett 1982).

Cold decking, a variation of drying at the stump, involves piling wood at roadside for later chipping. Wood in slash piles in eastern Canada has been reported at moisture contents as low as 32% in August (Ellingsen 1984). Cold decking trials on P.E.I. produced chips averaging 38% M.C. compared to 46% M.C. when green for wood cut in January and chipped in October (IEA 1983).

Active drying during storage is only practical for small volumes of wood chips. Furuseth et al (1981) studied drying in a number of residential sized chip bins in Finland. Piles as large as 75 cu.m (2650 cu.ft.) were easily dried from 38-42% to 27-32% in 4 months by ventilation which was predominantly passive. Chip storage in 20-40 cu.m containers which were ventilated for up to one month resulted in moisture contents lower than 30% in Norway (Gislerud 1982), Maine (Riley et al 1983) and Prince Edward Island (IEA 1983). Riley et al also reported that active drying before storage using a chip furnace was very inefficient and not recommended. For the purposes of this report, active drying is assumed to be limited to residential applications and most economical if done by the residential customer in his basement storage. The additional inventory and storage costs for the

supplier to dry the chips are expected to be prohibitive.

Active drying of large chip supplies during storage is not expected to be practical or economical. Experiments with ventilating approximately 500 ODt of chips in a warehouse and 125 ODt of chips in a covered outdoor pile resulted in no significant reduction in overall moisture content (IEA 1982). The outdoor pile increased to moisture contents greater than 60% in the outside zones which resulted in unmarketable chips. In general, large piles will have some passive drying from spontaneous heating as long as ventilation is provided. Any investment more than that to provide adequate pile ventilation is expected to have costs higher than the benefits that result.

In summary, advanced cutting, cold decking or harvesting dead wood are the only ways in which a producer can economically lower the moisture content of chips significantly. To illustrate the value of drying, recall that the ceiling price of chips was assumed to be $63/ODt for commercial chips at 45% M.C. Reduction of the moisture content to 35% would increase the comparable ceiling price by 5% to $66/ODt. Increased furnace efficiencies could increase this margin slightly. The overall impact of dry wood on chipping costs is not known with certainty, but is expected to be minor.

ii) Storage

Table 7.7 indicates that chip demand for most customers will be highest from December to March. The chip production and transportation system, however, is expected to operate on a year round basis. The production system can also be expected to be at low capacity during December, April and May when mud conditions are bad and weight restrictions may apply on secondary public roads. Weight restrictions typically reduce gross vehicle weights to 70% of normal capacity for 6-8 weeks in the spring. The restrictions typically apply during the period from early March to late May. Weight restrictions are not expected to have a great impact on chip and tree-section hauling because the fuels have low bulk densities, however, access by clay roads and to woodlots will be difficult or impractical during the above periods. Significant inventories are therefore required to meet the annual demand. A large supplier should have enough storage to provide supply for a minimum of 1 1/2 - 2 winter months during the spring thaw and any other periods where woods operations must be shut down due to cold weather, snow or mud problems. The storage facility should, therefore, be capable of holding approximately 20% of the annual demand. The inventory should be accessible by paved road and can be in tree section or chip form.

The major alternatives for storing wood fuel are:

1. Storage of wood in cold-decks at roadside,
2. Storage of wood in whole-trees/tree-sections at a central site,
3. Storage of chips at a central site,
4. Storage of chips at each customer's facility.

TABLE 7.7 ESTIMATED ANNUAL DISTRIBUTION OF WOOD CHIP DEMAND

Percent

Month	Heating Degree Days	Wood Chip Requirements	Comments
January	16	12	
February	15	12	
March	14	11	Spring Thaw
April	10	9	Spring Thaw
May	6	8	Spring Thaw
June	3	5	
July	2	4	
August	2	5	
September	3	6	
October	6	8	
November	9	9	
December	14	11	Mud Period
	100	100	

Sources: Environment Canada, P.E.I. Energy Corporation

Storage of wood at the stump area and chips at roadside are also possible but are not expected to be practical alternatives for storing large volumes because they are inaccessible during the critical supply period.

Storage of wood in cold-decks at roadside is expected to be used to build up inventories during periods when chip demand is low for periods when harvesting is difficult. For example, wood can be cold-decked during the summer for chipping during the winter months. The system is not practical for large volume storage during the spring when access to cold decks will be impractical.

Storage of large inventories of chips at the customers facility may be suitable for some large facilities; however, cost savings are not expected unless the heat plant is also the only major consumer. For supply to multiple customers, the only major savings will be the elimination of trucking from central storage to the customer's fuel bin. Increased costs will result because each customer will require equipment to move chips in and out of storage; increased levels of total inventory will be required for multiple sites; and storage facilities will be more costly. Many potential chip burning facilities are in sensitive areas where outside storage of fuel will be unacceptable, appearance of the storage building will be important and space may be unavailable. The potential savings resulting from tree-section storage are also eliminated.

Tree-sections can easily be stored outside without cover. The piles or cold decks can be expected to decrease in moisture content during storage until they become snow covered. The

inventory for spring thaw requirements must be accessible by paved road and large inventories should be stored on a paved surface. The major disadvantage of tree-section storage is handling and chipping of entangled and/or snow and ice covered tree sections can be difficult. Piles may also increase slightly in moisture content during the winter (Nylinder 1980).

The investment cost for a paved storage yard would be approximately $200,000/ha for excavation, fill and paving. With 5 m pile height, 100 OD Kg/cu.m pile density and 80% utilization, 4000 ODt could be stored per hectare. The investment cost would therefore be approximately $50/ODt of storage plus land costs. Tree-section storage is evaluated as part of a central facility in Section 8. Tree-section storage can also be used to supplement the inventories of small operators.

Fuel chips stored for extended periods should be protected from snow and rain. Most large users who store fuel chips outside such as pulp mills (hog fuel) and other large facilities have very high chip turnover. Chip piles of 4000-5000 ODt are common; however, these are often only a 2-3 week supply. The Burlington generating station in Vermont carries much of its inventory as pulp quality chips which have lower deterioration and risk of spontaneous combustion than whole tree chips (Carr 1979). Smaller piles of chips stored uncovered for extended periods increase in moisture content because more precipitation is absorbed (Nylinder 1980, IEA 1982). During mild winter weather, heat from the pile melts the snow and absorbs any moisture on the pile surface. In cold weather, the pile exterior

freezes preventing air circulation, increasing the risk of spontaneous combustion and making handling very difficult. On P.E.I., ice and large blocks of frozen chips have been delivered from outside piles as late in the year as July. Outside storage may also be unacceptable in developed areas where particles may be wind blown.

For the purpose of this report the following guidelines are used for chip storage:

1. Chips inventoried for periods of more than 1 or 2 weeks in piles of less than 500 ODt should be kept under cover, preferably on a paved surface.
2. Whole tree chip piles should be limited to heights of 6 m to prevent spontaneous combustion and handling difficulties.
3. The storage building should be well ventilated for passive air circulation.

The storage facility is required primarily to cover the chips from snow and rain. Pole barns are suitable for small to medium scale storage. Estimated costs of typical buildings including paving and construction are:

Volume	Floor Area	Capital[1] Cost	Capacity	Investment/ODt
1200 cu.m	200 sq.m	22,000	175 ODt	$125
2400	400	40,000	350	$115
3600	600	55,000	500	$110
7200	1200	110,000	1000	$110

[1] Approximately 25% of cost is for paving.

Investment costs for chip storage are approximately $110/ODt of storage plus land costs or approximately twice the cost of paved outside storage for tree sections. For comparative purposes the annual cost per ODt of storage, excluding land, for the various alternatives is:

	Paved Tree-Section Storage	Pole Barn Chip Storage Clay-Floor	Covered Chip Storage Paved
Expected Return[1]	16%	16%	16%
Capacity	4000 ODt	500 ODt	1000 ODt
Capital Cost	$200,000	$42,000	$110,000
Annual Amortization[1]	$33,700	$ 7,100	$ 18,600
Insurance	500	500	1,000
Total	$34,200	$ 7,600	$ 19,600
Cost/ODt	$ 8.55	$ 15.20	$ 19.60

1 75% debt at 14% interest, 25% equity at 22% return before tax, 20 year life.

The building costs are comparable to lease rates for buildings of similar size. The estimated cost of storage ranges from approximately $9/ODt for paved tree-section storage to $20/ODt for paved covered storage. Significantly higher costs would be expected for buildings located in sensitive urban areas and for specially designed, high volume storage buildings. Where available, significant savings could be realized by leasing a fully depreciated storage building; however, control and integration with a large operation could be complicated. The above costs do not include the costs of financing land which will vary significantly depending on location.

Additional storage costs result from the costs of handling chips and financing the inventory. For small operators, most inventory handling and final delivery will occur during the winter when idle construction equipment is available. Final delivery from storage will typically involve distances of less than 10 km. The small operator can contract a loader and truck until he reaches sufficient scale to purchase equipment. Based on typical rates for contracting a driver/operator with loader and truck, expected costs are $2.50/ODt to move chips in and out of storage and $5-7/ODt for delivery in large dump trucks. Additional interest costs of $1.75/ODt could be expected. Large facilities will have their own equipment which can reduce costs significantly.

The total cost of moving chips into storage, financing the storage building and inventory and delivering the chips from storage is clearly very high. The handling costs can only be avoided by direct delivery of chips. This is not practical for some periods during the winter. Storage costs can be reduced by tree section storage; however, investment and handling costs for equipment will be high. The costs of handling, storing and processing tree sections through a central facility are discussed in Section 8.

7.6 Screening

At the time of this report, chip screening was done by one Island contractor. Screening was required to remove oversize

material from the chips which would otherwise clog the augers in the fuel handling systems. The large P.E.I. contractor does not screen chips before delivery. However, the facility burning the chips supplies a hospital and is therefore monitored 24 hours per day. Large sticks, chunks and jams are cleared periodically by the boiler staff. Screening to remove large pieces is highly recommended for units which operate without full-time supervision. Significant fuel handling problems have been encountered with units that move large chips using small augers. Screening is essential for unsupervised operation of these units and for residential chips.

Screening can be performed at a number of locations. The most economical location is as part of the chipping process. High quality chippers with tight tolerances and a mechanism for removing or re-chipping large pieces should be sufficient for supplying most commercial and industrial scale systems. Since residential chips must be handled manually at some stage in the system, removal of large pieces by the customer may be satisfactory.

Where low-volume screening is required, a vibrating screen with blower or conveyor for reloading or piling is recommended. A high volume disk type screen would be more appropriate for a large central processing complex. Large mobile screens would not be appropriate for the scale of operation on P.E.I.

Estimated costs for screening chips are:

	Vibrating Screen System	Disk Screen System
Expected Return	18%	18%
Capacity (ODt/hr)	5	50
Capital Cost	$15,000	$ 75,000
Annual Amortization	$ 4,300	$ 21,400
Throughput (ODt/yr)	1,000	25,000
Estimated Cost/ODt		
Capital	$ 4.30	$ .90
Fuel	.60	.30
Maintenance	.50	.50
Additional Handling	1.50	
Total	$6.90	$1.70

1 75% debt at 14% interest, 25% equity at 30% return before tax, 5 year life, 25% salvage.

The expected cost of screening chips for a small contractor is high because he will not be capable of screening high volumes efficiently and he will incur additional handling costs. Similar results could be expected with screening equipment attached to the delivery vehicle. Screening facilities at a central processing facility are expected to cost approximately $1.50-2.00/ODt.

7.7 Summary

A number of attractive chip production systems have been identified. Small scale chipping is not expected to produce

chips at prices lower than ceiling prices because productivity is low.

Medium scale chipping with a mobile chipper and container system or a trailer mounted roadside chipper can produce chips at comparable cost. The roadside chipper may result in higher costs if a forwarder is required; however, the system will be more flexible for small operations. Costs of delivered chips ranging from $43-50/ODt can be expected based on a 30 km average haul. Cost reductions of $2/ODt can be expected if the average haul distance is reduced to 15 km.

Large scale chipping with a mobile chipper or a truck mounted roadside chipper can produce chips at an expected cost of $41-43/ODt delivered an average of 30 km.

Containerized trucking systems are expected to be the most economical for both low volume chipping and long distance (more than 30 km) transport under P.E.I. conditions. Dump trucks and dump trailers are suitable for medium to high volume chipping operations and hauls shorter than 30 km. Self unloading vans may be suitable for long hauls; however, the size and limited flexibility of the trucks limits their attractiveness for the small woodlots on P.E.I. Tree-section trucking is expected to result in costs for delivered wood of $33-35/ODt based on 30 km average hauls. The system may be appropriate for storing inventories and for chip production from central terminals.

Delivery of chips through storage will add significantly to costs; however, some storage will be necessary to meet demand during restrictive weather and road conditions. Inventories of

fuel are expected to be stored at roadside and at outside yards in tree-section form and under cover in chip form. Chip storage is expected to be the major form of storage for small and medium contractors because low cost handling equipment can be used. Tree-section storage is expected to increase in attractiveness with the scale of the operation because inventory requirements are higher and large volume handling equipment can be justified.

Table 7.7 summarizes the estimated achievable costs for large scale chip production based on 30% of output moving through central, covered chip storage, 30 km average hauls for primary transportation, 10 km average hauls for secondary transportation and the analysis in Section 7.1-7.6. The costs are based on contract rates for equipment and storage facilities purchased with no investment incentive. Estimated chip costs of $47/ODt can be expected for chips delivered directly to the customer. The above price is lower than the expected market prices. Chips delivered through storage are expected to have costs higher than the ceiling prices; however, average costs of $55/ODt could be achieved. This would still be attractive for customer conversion from oil. Estimated costs are based on expected achievable production levels for large scale systems operating at capacity. Significant price or investment incentives may be required during initial years to stimulate market growth and develop adequate markets. See Section 8.0 for further analysis.

Residential suppliers can be provided from the developing industry for an additional transportation cost of $2-3/ODt. Additional costs of $7-8/ODt can be expected for chips that must be screened separately by contractors.

Table 7.7. Forecast costs for chips based on contracting at standard equipment rates.

	Direct Delivery	Storage and Delivery	Weighted Average
Stumpage	$4.00	$4.00	$4.00
Felling	6.00	6.00	6.00
Forwarding & Chipping	21.00	21.00	21.00
Delivery	11.00	11.00	11.00
Storage[2]	--	10.00	3.00
Handling	--	5.00	2.00
Delivery	--	8.00	2.00
Interest		2.00	1.00
Profit[1] & Overhead	5.00	7.00	5.00
TOTAL	$47.00	$74.00	$55.00
Per 45% M.C. Tonne	$25.85	$40.70	$30.25

1 Note that a return of 30% before tax is also included in the equipment costing calculations.

2 Assumes storage is filled twice.

8.0 Chip Production Systems

In this section, chip production-delivery systems of a scale suitable for P.E.I. are discussed in relation to the projected market and the characteristics of supply. The five production systems discussed are:

1) Integrated Sawmill Business
2) Small Contractor
3) Medium Chip Contractor
4) Large Chip Contractor
5) Wood Chip Terminal

The systems are analyzed as separate integrated production systems. Transfers could easily occur between the businesses and the components of the systems could be operated by independent contractors. The major impact of separating the system components would involve the distribution rather than the level of sales and profits.

Economic analysis of each production system includes:

1) Equipment Configuration
2) Equipment and Investment Requirements
3) Financial Analysis

The configuration of the production system is based on the following premises:

1) Wherever possible, chips should be delivered directly from the chipper to the customer.
2) Direct delivery of chips will not always be possible or desirable because:

i) Many woodlots will be inaccessible during April and May and are difficult to access from June until August when farm crops are present;

ii) 65% of chip demand will occur from November to April while significant production will occur from May to October.

3) Inventories can be carried for extended periods without significant handling problems or deterioration in quality in:

i) unprocessed piles at roadside

ii) unprocessed piles at a central woodyard

iii) chip form under covered storage

iv) large uncovered piles for short periods

The financial analysis is based on the following major assumptions:

1) Prices and costs increase at 5% per year from the base of 1984 dollars.

2) The system begins operation at 50% of capacity for contractors and 75% of capacity for the chip terminal and expands to full capacity by the end of the five year period.

3) Interest rates remain constant at 14% (9% above inflation).

4) Twenty-five percent of the capital requirements are provided by equity based on an expected return of at least 25% after tax to compensate for the level of risk.

5) Tax rates of 25% apply while the business qualifies for

the Small Business Deduction.

6) The investment tax credit is treated as a government grant. This will approximate its net effect where the operator has sufficient taxable income.

7) Forgiveable loans, investment tax credits and similar incentives of up to 50% of investment costs apply to new operations. The incentive is also treated as a government grant.

Specific assumptions are discussed in relation to the production system.

8.1 Integrated Sawmill Business

Sawmills with adequate equipment to benefit from integrated-supply process 3600-4800 cu.m (1500-2000 cords) of logs or more annually. A typical mill would process 4000 cu.m (1670 cords) to produce 600 ODt of slabs, 225 ODt of sawdust and 125 ODt of shavings. Most mills of this size have at least a bucket loader, a dump truck which could be modified to haul 2.5 ODt of chips and a material handling blower. The mill could be converted to chip production with the following investment in equipment and storage:

100 mm Chipper	$8,000
Vibrating Screen	8,000
Blower	4,000
40 HP Engine	7,000
2400 cu.m pole barn[1]	20,000
Installation and Misc.	5,000
Total	$52,000

[1] Clay Floor, sawmills cost for lumber.

The mill would produce most of its residues during the peak period of operation from May to November. The storage facility would therefore be required to hold approximately 40% of the annual production. The system could easily be integrated into existing slab and sawdust/shavings systems with minimal cost. The incremental labour and overhead in operating the sawmill will be very low. The major incremental cost will be employing an operator to load and deliver chips.

The sales estimate is based on the full residue production of the mill of 950 ODt being marketed as a mixture of approximately 65% chips, 25% sawdust and 10% shavings. Only 65% of the fuel is actually therefore chipped. A weighted cost for the raw materials of $12/ODt based on the opportunity cost of lost slab and sawdust sales is used for the analysis. Total incentives of 50% of the investment cost are assumed to apply to the operation.

Figure 8.1 outlines the forecast income statement for the operation based on a price of $44/ODt. Complete analysis is included in Appendix 5 and summarized in Table 8.2. The financial analysis indicates that the operation is expected to yield a return on equity of approximately 59% at expected prices. The return from the operation is relatively insensitive to small changes in volumes and costs. At prices as low as $44/ODt, the operation would still yield a return on equity of slightly more than 25%. Significantly greater returns would result if the operation was brought up to capacity at a faster rate and mill production was higher. Returns may also be improved if screening

Table 8.2 Summary of Financial Analysis for Major Chip Supply Businesses.

	Integrated	Medium Contractor		Large Contractor		Wood Chip Terminal	
	Sawmill	#1	#2	Covered Storage	Outside Storage	Covered Storage	Outside Storage
Total Investment	$52,000	$260,000	$275,000	$665,000	$555,000	$2,320,000	$2,070,000
Capacity ODt/yr	950	3,500	3,500	10,000	10,000	40,000	40,000
Price:							
For 25% A. T. Return	$44	$61	$55	$54	$51	$53	$51
For 0% A. T. Return	$39	$54	$50	$49	$48	$48	$47
Discounted Returns:							
@ $50/ODt	59%	-25%	1%	8%	16%	12%	18%
@ $63/ODt	125%	34%	60%	71%	97%	78%	101%
Price required for 25% return if system begins at capacity, incentive reduced to 20% Investment Tax Credit, where applicable.	$43	$58	$56	$53	$51	N/A	N/A
Price for terminal located at major customer, 25% return						$49	$48
Per 45% M. C. Tonne	($24)	($32)	($31)	($29)	($28)	($27)	($26)

Figure 8.1. Projected income statement for Sawmill Residue Business.

Income Statement
For Year Ended

Price per ODt	$43.75		Raw Mat. per ODt		$12.00
	Year 1	Year 2	Year 3	Year 4	Year 5
Gross Sales	20781	25949	32402	40459	50520
Cost of Sales:					
Materials	5700	7117	8887	11097	13857
Wages	1723	2151	2686	3354	4188
Fuel	3325	4152	5184	6473	8083
Maintenance	2565	3203	3999	4994	6236
Delivery			Included		
Total	13313	16623	20757	25919	32364
Net Sales	7469	9326	11645	14541	18156
Operating Exp.:					
Gen. & Admin.	1039	1091	1146	1203	1263
Insurance	800	840	882	926	972
Depreciation	2750	2750	2750	2750	2750
Maintenance	1200	1260	1323	1389	1459
Total	5789	5941	6101	6268	6444
Operating Income	1679	3385	5544	8272	11712
Interest	4380	4104	3469	2444	1261
Earnings Before Tax	-2700	-719	2075	5829	10451
Income Tax	0	0	327	1385	4835
Net Income	-2700	-719	1748	4444	5616
Equity Inv. -7000					25500
Undeprec. Cap. Cost	28000	27950	25919	22402	19362
Cash Flow B.T.	50	2031	4825	8579	13201
Cap. Cost Allow.	50	2031	3518	3040	-6138
Taxable Income	0	0	1308	5539	19340
Income Tax	0	0	327	1385	4835
Cash Flow ex. Princ.	50	2031	4498	7194	8366
Principal	3177	3622	4129	4707	5366
Net Cash -7000	-3127	-1591	370	2487	28501
Discounted Return		25.1%			

can be eliminated and large volume trucks are contracted for delivery. At ceiling prices, the integrated sawmill is very profitable.

Approximately 8 mills of sufficient size to support the above type of operation exist on P.E.I. Smaller mills are expected to realize higher returns by selling their slabs to contractors.

8.2 The Small Contractor

The small contractor is expected to operate various components of the wood chip industry. The small contractor will be essential for supplying local chip markets until they reach sufficient size for a medium or large contractor. Small contractors are also expected to operate in small market areas and to supply large contractors and central facilities which may develop.

The small contractor is expected to provide harvesting, chipping and transportation capabilities. Harvesting operations will utilize conventional logging equipment adapted for whole-tree or tree-section transport. Minor modification of some equipment, such as fitting forwarders with bulk racks, may be required.

Table 8.2 outlines the major components of the chipping and transportation systems which could be provided by small contractors. The capital cost, expected capacity per operating hour and annual production volume are listed for each component. The equipment has high capital cost and is not expected to provide an adequate return for the contractor unless annual volumes are greater than 60% of capacity. Smaller markets can

Table 8.2. Estimated Capital Cost and Production Capacity of Selected Equipment Based on 1600 hr Operating Year and 30 km Average Haul for Trucks (Refer to Section 7 for details).

Inwoods-Chippers (clear-cut)	Capital Cost	Expected Production ODt/hr	Annual Capacity (ODt)
Small chipper, tractor, bin	$70,000	1.2	2000
Medium chipper, tractor, bin, grapple	156,000	2.5	4000
Large chipper, forwarder, bin, grapple	225,000	4.3	7000
Roadside Chippers			
Medium chipper, trailer, grapple	$82,000	3.0	5000
Medium chipper, truck, grapple	190,000	5.0	8000
Large chipper, truck, grapple	230,000	7.2	11500

Chip Trucks (12 ODt/hr chipper)	Capital Cost	Load (ODt)	Annual Volume (ODt)
Tandem dump truck	$70,000	3.5	4000
Dump trailer	120,000	7.0	5500
Tractor, live bottom van	150,000	13.5	7500
Truck, trailer, container system	170,000	12.0	8500
Tree Section Trucks			
Log truck, loader	$110,000	4.5	3500
Tractor, trailer, loader	140,000	10.5	6000
Truck, trailer loader	160,000	13.5	6500

only be supplied economically if high investment incentives are provided, used equipment is purchased and/or the equipment can be applied to other uses. Some equipment such as dump trucks and dump trailers is readily available for the present market. Other equipment which is more efficient, such as a container system, may be suitable once annual volumes are sufficient.

The major Island contractor uses a large chipper and dump trailers which are expected to be the most cost effective system for existing production levels and hauls. As markets grow the system can be made more flexible and more productive by truck-mounting the chipper and loader. The unit would be fully mobile and could chip wood efficiently as part of an integrated or a cold-decking system. Truck mounted units are maneuverable and easily transportable which makes them ideal for custom chipping of small woodlots and silvicultural thinnings.

As volumes increase, contractors can justify investment in more specialized and productive equipment. Mobile chippers or tree-sections forwarders will be required for economic extraction from thinning operations. A container system could improve overall productivity and flexibility in the transportation system. Development of tree-section storage may make investment in trucks modified to carry tree-sections attractive. The operation of high volume vans and chip trains is not expected to be attractive on P.E.I. because equipment flexibility is important and long hauls are not common.

Further analysis of the individual components of the chip-production system which may be operated by small contractors was included in Section 7.

8.3 The Medium Contractor

The medium contractor is expected to produce chips in conjunction with his other operations. The contractor operates a chipper and a storage facility to supply a market of 2000-4000 ODt/yr. Two configurations for medium scale production are outlined below.

i) Roadside Chipping

Contractor #1 operates a trailer mounted chipper to process wood from his existing operations and from cold-decks which he purchases (50% from each source). The contractor also owns a large dump truck which he uses for transportation and final delivery. The same equipment operator does the chipping and the delivery.

The chipping operation is based on a medium sized, trailer mounted chipper fed by a integral grapple loader. The unit has 6 ODt/hr capacity and produces 4.2 ODt/operating hour. The operation has a production capacity of approximately 3500 ODt/year or half the capacity of the chipper.

Trucking is done using a 3.5 ODt dump truck with an average haul of 15 km to storage or the customer and 10 km from storage to the customer. The contractor operates a 0.25 ha woodyard with a 3600 cu.m storage building. Additional inventory for peak periods is stored outside as tree-sections, roundwood or slabs which are delivered under contract and chipped when required. Approximately 500 ODt of chips and 200 ODt of tree sections would be required to meet peak inventory requirements at capacity. The operator would also require a small loader for chip handling at

the storage facility. Delivery will be provided by dump truck from storage and directly from the chipping operation. Approximately 30% of production is assumed to be delivered through central chip storage.

The contractor would require the following investment in equipment and storage:

Medium chipper	$82,000
Dump truck	70,000
Small loader	50,000
3600 cu.m pole barn (clay floor)	42,000
Land	2,000
Misc.	14,000
Total	$260,000

Total investment incentives of up to 50% are assumed to apply to processing equipment and 40% to the storage facility.

Figure 8.2 outlines the forecast income statement for the operation based on a price of $61/ODt. Complete analysis is included in Apendix 5 and summarized in Table 8.2. The operation is expected to yield a 25% return on equity at the above price. The financial analysis indicates that the small scale operation will not be profitable at expected prices; however, the operation can be attractive at ceiling prices, especially if production can be brought up to capacity quickly. The operation may also be more attractive if containerized transportation or higher volume markets are available.

Figure 8.2. Projected income statement for Medium Contractor No.1

Income Statement
For Year Ended

Price per ODt	$60.75		Raw Mat. per ODt		$23.00
	Year 1	Year 2	Year 3	Year 4	Year 5
Gross Sales	106313	132749	165760	206980	258450
Cost of Sales:					
Materials	40250	50259	62757	78363	97849
Wages	9050	11301	14111	17620	22001
Fuel	8413	10504	13117	16378	20451
Maintenance	8323	10392	12976	16203	20232
Delivery			Included		
Total	66035	82456	102960	128564	160534
Net Sales	40277	50293	62800	78416	97916
Operating Exp.:					
Gen. & Admin.	5316	5581	5860	6154	6461
Insurance	2600	2730	2867	3010	3160
Depreciation	23060	23060	23060	23060	23060
Maintenance	3000	3150	3308	3473	3647
Total	33976	34521	35094	35696	36328
Operating Income	6302	15772	27705	42720	61588
Interest	21774	18898	13504	5993	-3410
Earnings Before Tax	-15472	-3126	14201	36727	64998
Income Tax	0	0	207	8164	23236
Net Income	-15472	-3126	13994	28562	41763
Equity Inv. -42550					84000
Undeprec. Cap. Cost	170200	162612	142678	106246	79116
Cash Flow B.T.	7588	19934	37261	59787	88059
Cap. Cost Allow.	7588	19934	36432	27130	-4884
Taxable Income	0	0	828	32657	92942
Income Tax	0	0	207	8164	23236
Cash Flow ex. Princ.	7588	19934	37054	51622	64823
Principal	19311	22015	25097	28611	32616
Net Cash -42550	-11724	-2081	11957	23012	116207
Discounted Return		25.2%			

ii) Inwoods Chipping

Contractor #2 operates an inwoods, trailer mounted chipper powered by a tractor. It is used in conjunction with his thinning, stand reclamation and/or harvesting operations.

The chipping operation is based on a medium sized, grapple loaded chipper with 6 ODt/hr capacity which produces 2.3-2.5 ODt per operating hour. The chipper forwards chips to roadside and has a production capacity of approximately 3500 ODt/year.

The contractor will use a container system under contract for delivery which is the most efficient method of transportation for small scale production. He will also own 2 chip containers to supplement the containers provided by the trucker. The contractor will operate a storage facility comparable to that of contractor #1. Delivery to the customer will be provided by dump trucks under contract from storage and by direct delivery from the chipping operation. Average hauls are 15 km for primary delivery and 10 km for secondary delivery. Approximately 30% of production is assumed to be delivered through central chip storage.

The medium contractor would require the following investment in equipment and storage:

Medium chipper and tractor	$155,000
Small loader	50,000
Bins	12,000
3600 cu.m pole barn (clay floor)	42,000
Land	2,000
Misc.	14,000
Total	$275,000

Total investment incentives of up to 50% are assumed to apply to processing equipment and 40% to the storage facility.

Figure 8.3 outlines the forecast income statement for the operation based on a price of $55/ODt. The financial analysis which is included in Appendix 5 and summarized in Table 8.2 indicates that the medium scale operation will not be profitable at expected prices; however, the operation can be attractive at ceiling prices, especially if production can be brought up to capacity quickly. The increase in production and transportation efficiencies over Contractor #1 results in a significantly more profitable operation; however, the availability of a container system is assumed. Significant cost reductions for medium scale suppliers are difficult to achieve unless the need for covered storage can be eliminated.

8.4 Large Contractor

The large contractor is a full time chip supply contractor who owns a large truck mounted chipper, a container system and a storage facility to supply a market of 8,000-10,000 ODt.

The contractor operates a large truck mounted chipper with grapple loader, a container system and a large covered storage facility. He chips wood by hiring small contractors to supply wood to the chipper in a integrated operation and/or by purchasing cold-decked wood. Wood prices of $23/ODt are assumed based on some volume discounts.

The chipper has a capacity of 12 ODt/hr and produces 7.2 ODt/operating hour. The chipper has a production capacity of 11,500 ODt/year. Trucking is done with a container system to keep transportation costs down and to provide a medium sized vehicle for access to small woodlots. The container system

Figure 8.3. Projected income statement for Medium Contractor No.2.

Income Statement
For Year Ended

Price per ODt $55.25 Raw Mat. per ODt $11.00

	Year 1	Year 2	Year 3	Year 4	Year 5
Gross Sales	96688	120731	150753	188241	235051
Cost of Sales:					
Materials	19250	24037	30014	37478	46797
Wages	7506	9373	11704	14614	18248
Fuel	6125	7648	9550	11925	14890
Maintenance	12250	15296	19100	23850	29780
Delivery	18428	23010	28732	35876	44798
Total	63559	79364	99100	123743	154514
Net Sales	33129	41367	51653	64498	80537
Operating Exp.:					
Gen. & Admin.	3868	4061	4264	4477	4701
Insurance	2500	2625	2756	2894	3039
Depreciation	18935	18935	18935	18935	18935
Maintenance	2900	3045	3197	3357	3525
Total	28203	28666	29152	29663	30200
Operating Income	4926	12701	22501	34835	50337
Interest	18699	16555	12361	6398	-483
Earnings Before Tax	-13773	-3854	10140	28437	50820
Income Tax	0	0	0	6083	21791
Net Income	-13773	-3854	10140	22354	29029
Equity Inv. -35675					87750
Undeprec. Cap. Cost	142700	137538	122457	93381	70340
Cash Flow B.T.	5162	15081	29075	47372	69755
Cap. Cost Allow.	5162	15081	29075	23041	-17410
Taxable Income	0	0	0	24331	87165
Income Tax	0	0	0	6083	21791
Cash Flow ex. Princ.	5162	15081	29075	41289	47964
Principal	16191	18458	21042	23988	27346
Net Cash -35675	-11029	-3377	8033	17301	108368

Discounted Return 25.0%

keeps the truck fully productive and effectively separates the chipping and transportation systems. The truck will be operated for two shifts when production is high.

The contractor also owns a 0.5 ha woodyard with a 7200 cu.m storage building. Additional inventory for peak periods is stored outside as tree sections which are delivered under contract and chipped when required. Approximately 1000 ODt of chips and 1000 ODt of tree-sections would be required to meet peak inventory requirements at capacity. The contractor also owns a medium loader for chip handling at the storage facility. Delivery is provided from storage and directly from the chipping operation. Average hauls are 30 km for primary delivery and 10 km for secondary delivery. Approximately 30% of production is assumed to be delivered through central chip storage.

The large contractor would require the following investment in equipment and storage:

Large chipper and truck	$230,000
Container system	170,000
Medium loader	120,000
7200 cu.m pole barn (paved)	110,000
Paving (0.25 ha)	10,000
Land	5,000
Misc.	20,000
Total	$665,000

Total investment incentives of up to 50% are assumed to apply to processing equipment, 30% to the container system and 40% to the storage facility.

Figure 8.4 outlines the forecast income statement for the operation based on a price of $54/ODt. Complete analysis is included in Appendix 5 and summarized in Table 8.2. The financial analysis indicates that the large scale operation is marginally more attractive than the medium scale operations; however, longer hauls were assumed for the production of large volumes of chips. A chip price of $54/ODt was projected which is comparable to the price calculated in Section 7.

Figure 8.2 also summarizes the results for a large contractor assuming that covered storage can be eliminated without significant deterioration in chip quality. The elimination of the pole barn results in a saving of approximately $3/ODt. The results are again comparable to those calculated in Section 7.

8.5 Wood Chip Terminal

Assuming the market projections can be realized, Charlottetown and Summerside both have enough potential demand to support large wood terminals. Geographical analysis of the potential chip supply and demand distribution in Section 3 indicates that most wood could be coming to Summerside from the West. An appropriate location for the terminal would be in the area of St. Eleanors or Miscouche where industrial land can be acquired for less than $25,000/ha. Much of the supply to the Charlottetown market is expected to come from east of town. Location of the terminal would depend primarily on the location of the major suppliers. Industrial land in the Charlottetown area ranges to more than $75,000/ha. Similar land in the

Figure 8.4. Projected income statement for Large Contractor.

Income Statement
For Year Ended

Price per ODt	$53.75		Raw Mat. per ODt		$23.00
	Year 1	Year 2	Year 3	Year 4	Year 5
Gross Sales	268750	335580	419029	523229	653341
Cost of Sales:					
Materials	115000	143597	179305	223893	279569
Wages	17347	21661	27048	33774	42172
Fuel	20291	25337	31637	39504	49328
Maintenance	33265	41537	51867	64764	80869
Delivery			Included		
Total	185904	232132	289857	361936	451938
Net Sales	82846	103448	129172	161294	201403
Operating Exp.:					
Gen. & Admin.	8063	8466	8889	9333	9800
Insurance	3000	3150	3308	3473	3647
Depreciation	50990	50990	50990	50990	50990
Maintenance	5000	5250	5513	5788	6078
Total	67053	67856	68699	69584	70514
Operating Income	15794	35592	60473	91709	130888
Interest	48286	41935	30344	14344	-4423
Earnings Before Tax	-32492	-6342	30129	77365	135311
Income Tax	0	0	625	17265	55215
Net Income	-32492	-6342	29504	60100	80096
Equity Inv. -95750					216500
Undeprec. Cap. Cost	383000	364502	319855	241235	181941
Cash Flow B.T.	18498	44648	81119	128355	186301
Cap. Cost Allow.	18498	44648	78619	59295	-34559
Taxable Income	0	0	2500	69060	220860
Income Tax	0	0	625	17265	55215
Cash Flow ex. Princ.	18498	44648	80494	111090	131086
Principal	43456	49540	56476	64382	73396
Net Cash -95750	-24958	-4893	24018	46708	274190
Discounted Return		25.6%			

Southport area and other surrounding communities can be acquired for less than $50,000/ha. A major problem with locating in the Southport area is that wood coming from the east will have to be trucked both ways over the Hillsborough Bridge. For the purpose of this report, the terminal is assumed to be located north of Charlottetown on industrial property costing $50,000/ha.

The terminal will include a high volume chipper, screening and re-chipping system and a moving conveyor system which can be moved to load the storage facility or to pile chips outside for short term storage. The plant will have sufficient capacity to store 1500 ODt of fuel under cover which will provide a one week supply during the peak season. Paved outside storage will be provided for approximately 6500 ODt of unprocessed material (approximately 1.75 ha) to meet demand during spring thaw.

The wood terminal will also include 4 whole-tree trucks for acquiring tree sections, whole trees and residuals at roadside from woods contractors and 2 large volume dump trailers for delivery to customers. The trucks will have to be operated for 2 shifts during peak periods. Chips, slabs, residues and contract wood may also be purchased to supplement fuel supplies. Average wood prices of $22/ODt at roadside have been assumed based on some volume discounts.

The wood chip terminal would require the following investment in equipment and storage:

4 Whole tree trucks	$560,000
2 Dump-trailer trucks	250,000
2 Medium loaders	240,000
Chipper and equipment	100,000
Disk screen and re-chipper	100,000
Handling and conveying system	90,000
Truck scale	150,000
11,000 cu.m storage	250,000
Office	30,000
Levelling, fill, paving	300,000
Land	100,000
Engineering and installation	150,000
Total	$2,320,000

Total investment incentives of up to 40% are assumed to apply to processing equipment and the storage facility.

Figure 8.5 outlines the forecast income statement for the operation based on a price of $53/ODt. Complete analysis is included in Appendix 5 and summarized in Table 8.2. The financial analysis indicates that the chip terminal can provide an attractive return at the above price; however, the terminal is only marginally more attractive than the large contractor. Savings of up to $4/ODt can be expected if the terminal can be integrated with a large plant which is also the major consumer.

Figure 8.2 also summarizes the results for a wood-chip terminal assuming that covered storage can be eliminated without significant deterioration in chip quality. The elimination of the chip warehouse results in a saving of approximately $2/ODt. The overall saving is marginal because a storage capacity of only 4% of the annual demand has been assumed.

Figure 8.5. Projected income statement for Wood Chip Terminal.

Income Statement
For Year Ended

Price per ODt	$2.60		Raw Mat. per ODt		$22.00
	Year 1	Year 2	Year 3	Year 4	Year 5
Gross Sales	1578000	1780455	2008885	2266622	2557426
Cost of Sales:					
Materials	660000	744677	840218	948017	1069646
Wages	141000	151514	162813	174954	188000
Fuel	120000	128948	138564	148897	160000
Maintenance	123000	138620	148956	160064	172000
Delivery			Included		
Total	1053000	1163759	1290551	1431931	1589646
Net Sales	528000	616696	718334	834690	967780
Operating Exp.:					
Gen. & Admin.	63120	66276	69590	73069	76723
Insurance	20000	21000	22050	23153	24310
Depreciation	239160	239160	239160	239160	239160
Maintenance	40000	42000	44100	46305	48620
Total	362280	368436	374900	381687	388813
Operating Income	165720	248260	343434	453004	578967
Interest	236444	193249	132927	60684	-22209
Earnings Before Tax	-70724	55011	210507	392320	601176
Income Tax	0	0	40760	142500	279722
Net Income	-70724	55011	169747	249820	321453
Equity Inv. -454000					
Undeprec. Cap. Cost	1816000	1647564	1353393	1066766	711000
					840842
Cash Flow B.T.	168436	294171	449667	631480	840336
Cap. Cost Allow.	168436	294171	286627	225924	129842
Taxable Income	0	0	163039	405556	710494
Income Tax	0	0	40760	142500	279722
Cash Flow ex. Princ.	168436	294171	408907	488980	560613
Principal	206048	234895	267780	305269	348007
Net Cash -454000	-37612	59276	141127	183710	923606
Discounted Return		25.2%			

8.6 Summary

Medium and large scale chip production is feasible at prices significantly lower than expected ceiling prices. Prices ranging from $44/ODt to $61/ODt are expected for various types of producers. The only businesses which are feasible at the expected price level are the integrated sawmill, the large contractor without covered storage and the chip terminal without covered storage. The additional risk involved in operating a large chip terminal is expected to outweigh the marginal price reduction achieved relative to the large contractor. Wood chip terminals may be attractive where large volumes of residuals, waste and other products must be processed for the same market. Most production on P.E.I. is expected to be from whole trees which can be processed efficiently at the harvest site.

Anticipated prices are based on a number of critical assumptions:

1) Economical conversion of heating facilities to wood depends on the price of oil which is the major alternative fuel on P.E.I. World oil markets are presently very unstable and may result in significant downside risk.

2) The financial analysis is based on an assumed price for wood which includes stumpage, harvesting and profit. Reductions in the price of wood can be expected for stand reclamation, high volume stands and more efficient operations. Reductions in wood prices reduce chip prices proportionally.

The overall impact of the above cost factors on chip costs is difficult to determine with certainty. In the long term, wood production costs significantly below those quoted are not expected.

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APPENDIX 1

Basis of Major Market Estimates

Estimated Equivalent Wood Consumption for Major Market Areas on P.E.I.

Assumptions

Residential:	
Consumption/Building(GJ) - space heating	120
- heat and hot water	175
Oil Combustion Efficiency	78%
Overall Wood Combustion Efficiency(30%MC)	61%
Non-residential:	
Estimated Backup Capacity	50%
Estimated Average Load Factor	40%
KJ/L Oil	38500
Oil Combustion Efficiency	80%
1000KJ/tonne Wood (OD)	20000
Overall Wood Combustion Efficiency(45%MC)	57%

Conversions

From	x	To
Kw	0.10201	Boiler hp
	3413.00	Btu/hr
	3.51933	lbs/hr steam from 212F
	1.34100	Elect. hp

Residential Consumption in Major Markets

Market Area	Private Dwellings	Est. Oil Cons. (kL)	Est. Wood Cons. (ODt)
Charlottetown	9235	28784	70852
Summerside	3304	10298	25349
Montague	540	1683	4143
Souris	420	1309	3222
Kensington	338	1054	2593
Alberton	318	991	2440
Tignish	317	988	2432
Georgetown	216	673	1657
Borden	176	549	1350
	14472	46329	114039

References: Statistics Canada 1981, PEI Trade Directory, IEA Estimates

Estimated Equivalent Wood Consumption for Major Market Areas on Prince Edward Island

Market Area	Total Site Horsepower 20-49	50-99	100-149	150-199	200-299	300-499	500-1000	3000	12000	Est. Tot. Hp	Est. Tot. Kw	Est. Kw Cap.	Est. Oil Cons.(kL)	Est. Wood Cons.(ODt)
Charlottetown	63	38	14	9	6	3	6		1*	14680	143908	71954	23576	63695
Summerside	30	17	5	2	4	3	2	1		9700	95089	47545	15578	42087
Kensington	3	1						1		3180	31174	15587	5107	13798
Montague/Georgetown	10	2	1	2	1		1			1825	17890	8345	2931	7919
O'leary/Bloomfield	3	2	1	1		1				955	9362	4681	1534	4144
Souris	5	3	1		1					775	7597	3799	1245	3363
Bedeque/Kinkora	2	1					1			745	7303	3652	1196	3232
Tignish	2	4	1	1						670	6568	3284	1076	2907
Alberton	1	3		2						610	5980	2990	980	2647
St. Peters/Morell	2	3	1							420	4117	2059	675	1822
Murray River/Gasper.	2	4								370	3627	1814	594	1605
Hampshire		2		1						325	3186	1593	522	1410
Wellington	2	2								220	2157	1078	353	955
Eldon/Belle River	2		1							195	1912	956	313	846
Tyne Valley	3	1								180	1765	882	289	781
North Lake/Kingsboro	3	1								180	1765	882	289	781
Vernon River/Kinross	1		1							160	1568	784	257	694
Malepeque/Park Corner		2								150	1470	735	241	651
Mt. Stewart/Ft. Aug.	2	1								145	1421	711	233	629
Rusticoville	4									140	1372	686	225	607
Hunter River		1								75	735	368	120	325
Bonshaw/Crapaud	2									70	686	343	112	304
Dundas/Fortune	2									70	686	343	112	304
Corran Ban	1									35	343	172	56	152
TOTAL	145	88	26	18	12	7	10	2	1*	35875	351683	175841	57614	155658
Range Midpoint	35	75	125	175	250	400	600	3000	12000*					

* The Maritime Electric boilers provide backup electrical generation capacity and are not included in the calculations

APPENDIX 2

Fuel Supply Estimates

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1984 Sawmill Survey Results	1
Sustainable Yield Calculations	5

1984 Sawmill Survey Results

NAME	ADDRESS	SEASON	LOGS (CU.M) 1982 PROD.	1984 PROD.	% HARD	% PLANED	
Baker's Sawmill	Lakeville	Mar/Dec	1440	1080	8	90	
MacDougall's Lumber	St. Peter's Bay	Jan/Dec	1200	660	0	90	
TOTAL SOURIS			2640	1740			
Cook's Mill	Wood Islands	Jan/Dec	1560	1560	3	60	
Edward Smith	Cardigan	May/Dec		1140	2	0	
Gordon's Mill	Cardigan	May/Dec		460	0	95	
Henderson Lumber Co.	Georgetown	Jan/Aug	9600	8400	0	95	
John MacPherson	Belfast	Jan/Dec	1200	1200	3	45	E
Leard's Mill	Lorne Valley	May/Dec	480	240	0	33	
Lester Larsen	Eldon	Apr/Dec	480	480	0.5	50	E
MacKinnon's Lumber	Glenmartin	May/Dec	1440	600	0	85	E
Moore's Lumber Mill	Murray River	Jan/Dec	1800	2040	6	85	E
Progressive Wd Prod.	Iona	Apr/Dec		480	0	90	
Winston Hancock	Portable	Apr/Nov	2400	2070	0	20	
TOTAL MONTAGUE			18960	18670			
Bob Moore	Springvale	Jan/Dec	4800	4200	1	92	E
Elmer Murphy	Millvale	-		480	1	12	E
Heritage Mills	Sherwood Road	Jan/Dec	4800	4200	0	100	
Larsen's Sawmill	Rose Valley	Jan/Dec	4060	3600	4	50	
Pigot's Mill	Mt. Stewart	Jan/Dec	720	1740	14	50	
Wisener's Mill	Watervale	Apr/Dec	3600	3720	0	75	E
TOTAL CHARLOTTETOWN			17980	17940			
Arsenault Sawmill	St. Chrysostome	Apr/Dec	3840	4300	0	85	
Don Gillis	Miscouche	Mar/Dec	960	1560	0	10	
Gordon MacKinnon	Breadalbane	May/Nov	480	600	0	50	E
Schurman Windows	Summerside	Jan/Dec	Finishing Mill		0	100	
Simpson's Mill	Hope River	Mar/Dec	1440	1200	5	75	
Weeks & Son	Pleasant Valley	May/Nov	1920	2400	0	75	
The Wood Corp.	St. Eleanors	Jan/Dec	7200	7920	0	5	
TOTAL SUMMERSIDE			15840	17980			
Betts Mills	Glenwood	Jan/Dec	4800	7200	2	20	
Henry MacAusland	O'Leary	Aug/Dec		2400	5	0	
Morrison's Mills	Hebron	Jan/Dec	4800	4800	0	0	
Peter Gallant	Piusville	Apr/Nov	1800	1200	0	75	
TOTAL O'LEARY			11400	15600			
Leoville Ind.	Tignish	Jul/Dec	Finishing Mill		70	100	
Tignish Co-op	Tignish	Jan/Dec	1680	2400	15	25	
TOTAL TIGNISH			1680	2400			
TOTAL PEI			68500	74330			

Note: Mills with less than 200 cords production in 1984 not included

E - estimated based on standards (see Appendix 6)

1984 Sawmill Survey Results

NAME	SLABS (OD TONNES) 1982 PROD.	1984 PROD.	1984 SALES	PRESENT MARKET	SAWDUST (OD TONNES) 1982 PROD.	1984 PROD.	1984 SALES	PRESENT MARKET
Baker's Sawmill	109	164	164	Fuel		60	12	Fuel
MacDougall's Lumber	305	290	290	Fuel		37 E	0	-
TOTAL SOURIS	414	454	454		0	97	12	
Cook's Mill	290	260 E	260	Fuel		80 E	80	Fuel
Edward Smith		170 E	170	Fuel		65 E	0	-
Gordon's Mill		165 E	165	Fuel		25	0	-
Henderson Lumber Co.		1250 E	1250	Chips	2925	472 E	300 E	Pulp
John MacPherson	145	180	180	Fuel	174	70 E	35	Fuel
Leard's Mill	36	41	35 E	Fuel	644	15	4	Fuel
Lester Larsen		70	70	Fuel	68	25	25	Fuel
MacKinnon's Lumber	66	90	90	Fuel		17	3	FUEL
Moore's Lumber Mill	72	250	250	Fuel	66	115	56	Fuel
Progressive Wd Prod.		72 E	72	Chips		28 E	0	-
Winston Hancock	Sawmill is portable, left on site							
TOTAL MONTAGUE	609	2548	2542		3877	912	503	
Bob Moore	492	630	630	Fuel	147	275	275	Misc
Elmer Murphy		60	60	Fuel		27	22	Misc
Heritage Mills	259	315	315	Fuel	170	235	235	Agric
Larsen's Sawmill	1227	450	450	Fuel		200	200	Fuel
Pigot's Mill	57	260 E	175	Fuel	63	105 E	105	Fuel
Wisener's Mill	423	450	400 E	Fuel	35	55	15	Fuel
TOTAL CHARLOTTETOWN	2458	2165	2030		415	897	852	
Arsenault Sawmill	580	700	700	Fuel	112	250	162	Fuel
Don Gillis	145	200	200	Fuel		90 E	90	Misc
Gordon MacKinnon	36	100	100	Fuel		35 E	17 E	Fuel
Schurman Windows		0	0	-		-	-	-
Simpson's Mill		180	180	Fuel		70 E	35	Misc
Weeks & Son	181	225	225	Fuel		125	125	Agric
The Wood Corp.	508	850	850	Fuel	739	445	445	Agric
TOTAL SUMMERSIDE	1450	2255	2255		851	1015	874	
Betts Mills	544	1080	1080	Fuel		405 E	200	Agric
Henry MacAusland		360 E	360	Fuel		135 E	100	Misc
Morrison's Mills	145	70	70	Fuel		270 E	0	-
Peter Gallant	109	180 E	180	Misc	29	67 E	67	Misc
TOTAL O'LEARY	798	1690	1690		29	877	367	
Leoville Ind.		0	0	-	38	17	17	Fuel
Tignish Co-op	109	360 E	360	Fuel		135 E	17	Misc
TOTAL TIGNISH	109	360	360		38	152	34	
TOTAL PEI	5838	9472	9331		5210	3950	2642	

E - estimated based on standards (see Appendix 6)

1984 Sawmill Survey Results

NAME	SHAVINGS (OD TONNES) 1982 PROD.	1984 PROD.	1984 SALES	PRESENT MARKET
Baker's Sawmill		40 E	4	Agric
MacDougall's Lumber		25 E	25	Agric
TOTAL SOURIS	0	65	29	
Cook's Mill		44 E	6	Misc
Edward Smith		0	0	-
Gordon's Mill		15 E	6 E	Trails
Henderson Lumber Co.	1828	300 E	220 E	Pulp
John MacPherson		0	0	With Sawdust
Leard's Mill		6 E	6	Agric
Lester Larsen		7	7	-
MacKinnon's Lumber		11	0	-
Moore's Lumber Mill		46	0	-
Progressive Wd Prod.		15 E	0	-
Winston Hancock	Sawmill is portable, left on site			
TOTAL MONTAGUE	1828	444	245	
Bob Moore		110	110	Agric
Elmer Murphy		3	3	Agric
Heritage Mills		125	125	Agric
Larsen's Sawmill		55	55	Agric
Pigot's Mill		27	22	Agric
Wisener's Mill	11	35	0	-
TOTAL CHARLOTTETOWN	11	355	315	
Arsenault Sawmill		40	4	Agric
Don Gillis		6 E	6	Agric
Gordon MacKinnon		13 E	0	-
Schurman Windows		493	470	Fuel
Simpson's Mill		31 E	31	Agric
Weeks & Son		55	27	Agric
The Wood Corp.		0	0	With Sawdust
TOTAL SUMMERSIDE	0	638	538	
Betts Mills		43 E	6	Misc
Henry MacAusland		0	0	-
Morrison's Mills		0	0	-
Peter Gallant		34 E	34	Misc
TOTAL O'LEARY	0	77	40	
Leoville Ind.	10	0	0	With Sawdust
Tignish Co-op		22 E	19	Misc
TOTAL TIGNISH	10	22	19	
TOTAL PEI	1849	1601	1186	

E - estimated based on standards (see Appendix 6)

1984 Sawmill Survey Results

NAME	MILL EQUIPMENT
Baker's Sawmill	Dump Truck, Tractor Scoop
MacDougall's Lumber	Dump Truck, Shavings Storage
TOTAL SOURIS	
Cook's Mill	Tractor Scoop, Dump Truck, Shavings/Sawdust Storage
Edward Smith	Log Truck, Dump Truck, Tractor With Scoop
Gordon's Mill	Tractor Scoop
Henderson Lumber Co.	Clam Shell Bins for Chips, Shavings, Sawdust
John MacPherson	Dump Truck, Tractor Scoop, Waste Trailer
Leard's Mill	Tractor Scoop
Lester Larsen	Dump Truck, Tractor Scoop, Sawdust Trailer
MacKinnon's Lumber	Log Truck, Dump Truck
Moore's Lumber Mill	Tractor Scoop, Sawdust Storage
Progressive Wd Prod.	Skidder, Loader
Winston Hancock	
TOTAL MONTAGUE	
Bob Moore	Dump Truck, Loader, Sawdust Storage
Elmer Murphy	Tractor Scoop
Heritage Mills	Loader, Log Truck, Dump Truck
Larsen's Sawmill	Dump Truck, Loader, Sawdust/Shavings Storage
Pigot's Mill	Dump Truck, Tractor Scoop, Sawdust Storage
Wisener's Mill	Dump Truck, Log Truck, Loader
TOTAL CHARLOTTETOWN	
Arsenault Sawmill	Log Truck, Dump Truck, Tractor Trailer, Loader
Don Gillis	Dump Truck, Log Truck, Tractor Scoop
Gordon MacKinnon	Dump Truck, Log Truck, Tractor Scoop
Schurman Windows	Charge $2.50/mile for 1000 cu.ft self unloading van
Simpson's Mill	Sawdust, Shavings Storage
Weeks & Son	Dump Truck, Log Truck, Tractor Scoop, Shavings Storage
The Wood Corp.	Log Truck, Loader, Hopper for sawdust, slabs
TOTAL SUMMERSIDE	
Betts Mills	Logging Truck, Dump Truck
Henry MacAusland	Flat Bed, Back Hoe
Morrison's Mills	Log Truck, Tractor with Scoop
Peter Gallant	

Assumptions

Gross Total Volume:
Based on 1982 Inventory - Total Harvestable Biomass

Annual Sustainable Harvest:

Average Growth Period-Softwood (years)	50
Average Growth Period-Hardwood (years)	50
Amount of land available for management	55%
Amount of harvestable volume recoverable	85%

Sawlog Harvest:

Percent Softwood	90%
Harvest multiplier to reflect tot. biomass removed	160%

Pulpwood Harvest:
Includes posts and other miscellaneous products

Percent Softwood	92%
Harvest multiplier to reflect tot. biomass removed	160%

Fuelwood Harvest:

Percent Softwood		10%
Harvest multiplier to reflect tot. biomass removed		140%
Distributed by population		Per Wood Burning Household
Urban usage	30.0%	2.3 Cords (average)
Rural Usage	69.0%	5.2 Cords (average)

Conventional Waste:

Percent recoverable	75%

Conversions:

Average Moisture Content Green Wood	50.0%
Cords softwood to oven dry tonnes	0.909
Cords hardwood to oven dry tonnes	1.000

(Cords)	Souris	Montague	Char'tn	Sum'side	O'leary	Tignish	TOTAL
Sawlogs	936	10047	9654	9675	8395	1293	35000
Fuelwood	8733	15457	35878	24327	9842	5766	100000
Pulp&Misc	4000	7200	4800	3200	400	400	20000
Households	2434	4308	17116	9452	2743	1607	37660
% Urban	0.0%	0.0%	51.5%	35.0%	0.0%	0.0%	
Pulp&Misc	20%	36%	24%	16%	2%	2%	100.0%
Inventory % Softwd	51.8%	50.1%	45.6%	48.2%	48.5%	48.5%	

Total Harvestable Biomass (Oven Dry Tonnes)

	Softwood	Hardwood	Total
Souris			
Tot. Harvestable Biom.	2812999	2617501	5430500
Sustainable Harvest	30943	28793	59736
Less: Sawlog Harvest	1225	150	1375
Fuelwood	1111	11004	12115
Pulp & Misc.	5352	512	5864
Surplus Biomass	23254	17127	40381
Plus Convent. Waste	2088	2313	4401
AVAILABLE BIOMASS	25342	19439	44782
Montague			
Tot. Harvestable Biom.	4323630	4306370	8630000
Sustainable Harvest	47560	47370	94930
Less: Sawlog Harvest	13151	1608	14759
Fuelwood	1967	19476	21443
Pulp & Misc.	9634	922	10556
Surplus Biomass	22808	25365	48173
Plus Convent. Waste	6830	4440	11270
AVAILABLE BIOMASS	29638	29805	59443
Charlottetown			
Tot. Harvestable Biom.	3835872	4576128	8412000
Sustainable Harvest	42195	50337	92532
Less: Sawlog Harvest	12637	1545	14181
Fuelwood	4566	45207	49773
Pulp & Misc.	6423	614	7037
Surplus Biomass	18569	2971	21541
Plus Convent. Waste	6339	9358	15696
AVAILABLE BIOMASS	24908	12329	37237
Summerside			
Tot. Harvestable Biom.	2644011	2841489	5485500
Sustainable Harvest	29084	31256	60341
Less: Sawlog Harvest	12664	1548	14212
Fuelwood	3096	30652	33747
Pulp & Misc.	4282	410	4691
Surplus Biomass	9042	-1353	7690
Plus Convent. Waste	5429	6471	11900
AVAILABLE BIOMASS	14472	5118	19590

References: Resource Ventures Inc. 1983, Pratt 1978, Canada-PEI Resource Development Agreement 1983

Total Harvestable Biomass (Oven Dry Tonnes)

O'Leary			
Tot. Harvestable Biom.	1959400	2080600	4040000
Sustainable Harvest	21553	22887	44440
Less:Sawlog Harvest	10989	1343	12332
Fuelwood	1252	12401	13653
Pulp & Misc.	535	51	586
Surplus Biomass	8777	9091	17868
Plus Convent. Waste	3509	2772	6281
AVAILABLE BIOMASS	12286	11863	24150
Tignish			
Tot. Harvestable Biom.	630500	669500	1300000
Sustainable Harvest	6936	7365	14300
Less:Sawlog Harvest	1692	207	1899
Fuelwood	734	7265	7999
Pulp & Misc.	535	51	586
Surplus Biomass	3974	-159	3815
Plus Convent. Waste	784	1481	2265
AVAILABLE BIOMASS	4758	1322	6080
Provincial Total			
Tot. Harvestable Biom.	16206412	17091588	33298000
Sustainable Harvest	178271	188007	366278
Less:Sawlog Harvest	52358	6400	58758
Fuelwood	12726	126004	138730
Pulp & Misc.	26761	2560	29321
Surplus Biomass	86425	53043	139468
Plus Convent. Waste	24979	26834	51814
AVAILABLE BIOMASS	111404	79878	191282

References: Resource Ventures Inc. 1983, Pratt 1978, Canada-PEI Resource Development Agreement 1983

APPENDIX 3

Chip Production Systems, 1984

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Equipment Costing Calculations

Basis

- capital costs include assembly, accessories and taxes where applicable
- operating costs are calculated per operating hour based on P.E.I. conditions and the assumptions listed
- machines are assumed to operate 8 hours per day for 200 days per year. Two shift operation could reduce operating costs slightly.
- financing assumes a 14% interest rate and 30% return on equity before tax. A minimum 25% return would be expected to justify the level of risk.
- volume estimates are for full trees or chips with average 200 m forwarding distance.
- representative types of equipment are summarized in Appendix 6.

Tractor

- 40-50 Hp tractor with winch outfitted for woods work
- productivity is estimated at 8 ODt/day for winching tree-sections from a thinning operation.

Feller Buncher

- wheeled, medium sized feller buncher with a 40-50 cm shear
- productivity is estimated at 60 ODt per operating day for clearcutting under average conditions.

Small Skidder

- wheeled skidder with 75-85 Hp engine, winch and chokers
- productivity is estimated at 22 ODt per operating day for clearcutting under average conditions.

Medium Skidder

- wheeled skidder with 100-120 HP engine, winch and chokers
- productivity is estimated at 28 ODt per operating day for clearcutting under average conditions.

Grapple Skidder

- medium wheeled skidder with 100-120 Hp engine, boom and grapple.
- productivity is estimated at 32 ODt per operating day for clearcutting under average conditions in combination with a feller buncher.

Forwarder

- single axle wheeled forwarder with 100-120 Hp engine and extended rack for carrying 2.0 ODt/load of whole trees or tree sections.
- productivity is estimated at 30 ODt per operating day for clearcutting tree sections under average conditions.
- productivity is estimated at 24 ODt per operating day for thinning operations.

Chip Forwarder

- similar to above with 3.0 ODt chip bin
- productivity is estimated at 55 ODt per operating day in conjunction with chipper/bin and containers.

Bucket Loader

- medium bucket loader for handling wood chips.

Chipper #1

- small chipper front mounted on tractor with 1.5 ODt, rear mounted container.
- estimated cost:

50-80 Hp tractor	$50,000
Chipper	15,000
Chip bin	5,000
	$70,000

- productivity of chipper is estimated at 3 ODt/hr

Chipper #2

- medium chipper on trailer with grapple loader and power unit.

- estimated cost:

Chipper and trailer	$50,000
Loader	$17,000
80-120 Hp engine	$15,000
Total	$82,000

- productivity of chipper is estimated at 6 ODt/hr.

Chipper #3

- medium chipper on trailer with grapple loader and chip bin powered by wood tractor.

- estimated cost:

80 Hp tractor	$60,000
Chipper and trailer	65,000
Loader	16,000
2.5 ODt chip bin	15,000
Total	$156,000

- productivity of chipper is estimated at 6 ODt/hr

Chipper #4

- medium, powered chipper on single axle truck with grapple loader and cab.

- estimated cost:

Truck	$65,000
Chipper and engine	100,000
Loader and cab	25,000
Total	$190,000

- productivity of chipper is estimated at 8 ODt/hr.

Chipper #5

- medium, powered chipper on single axle forwarder with grapple loader and chip bin.

- estimated cost:

Forwarder	$110,000
Chipper and engine	100,000
2.5 ODt bin	15,000
Total	$225,000

- productivity of chipper is estimated at 8 ODt/hr.

Chipper #6

- large, powered chipper on tandem truck with grapple loader and cab.

- estimated cost:

Truck	$75,000
Chipper and engine	130,000
Loader and cab	25,000
Total	$230,000

- productivity of chipper is estimated at 12 ODt/hr.

Chipper #7

- large, powered chipper on rebuilt boggie axle forwarder with grapple loader and chip bin.

- estimated cost:

Forwarder	$110,000
Chipper and engine	135,000
3.0 ODt chip bin	15,000
Total	$260,000

- productivity of chipper is estimated at 12 ODt/hr.

Chipper #8

- very large, semi-mobile chipper with grapple
- estimated cost: $310,000
- estimated productivity of chipper is 30 ODt/hr.

Trucks

- small dump truck with 3.5 ODt box $70,000
- 40 cu.m log truck with loader

Truck and box	$90,000
Loader	25,000
	$115,000

- tractor and dump trailer with 7.0 ODt box $120,000
- tractor and live bottom 15 ODt van

tractor	$85,000
45' van	35,000
live bottom	30,000
	$150,000

- container truck and trailer with 15 ODt in 2 containers

Truck	$90,000
Container unit	25,000
Trailer	20,000
6 containers	35,000
	$170,000

- whole tree tractor, 90 cu.m pulp trailer and loader

Tractor	$85,000
Trailer with sides	30,000
Loader	25,000
	$140,000

- whole-tree 40 cu.m truck, 75 cu.m trailer and loader

Truck and box	$95,000
Trailer with sides	40,000
Loader	25,000
	$160,000

Basis for Hourly Equipment Charge Estimates

	Feller Buncher	Tractor & Winch	Small Skidder	Medium Skidder	Grapple Skidder	Medium Forwarder	Chip Forwarder	Medium Loader
Equipment Cost	140000	35000	70000	80000	95000	110000	140000	120000
Residual Value	25%	25%	25%	25%	25%	25%	25%	25%
Deprec. Life	5	5	5	5	5	5	5	5
Maint. % of Depr	100%	100%	100%	100%	100%	100%	100%	80%
Insurance Rate	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	1.0%
Tax Rate	25%	25%	25%	25%	25%	25%	25%	25%
CCA	30%	30%	30%	30%	30%	30%	30%	30%
Financing								
Debt	75%	75%	75%	75%	75%	75%	75%	75%
Interest Rate	14%	14%	14%	14%	14%	14%	14%	14%
Equity	25%	25%	25%	25%	25%	25%	25%	25%
Return	30%	30%	30%	30%	30%	30%	30%	30%
Cost Cap.B.T.	18.00%	18.00%	18.00%	18.00%	18.00%	18.00%	18.00%	18.00%
A.T. Investment	118125.00	29531.25	59062.50	67500.00	80156.25	92812.50	118125.00	101250.00
PV Salvage A.T.	12908.38	3227.10	6454.19	7376.22	8759.26	10142.30	12908.38	11064.33
Net	105216.62	26304.15	52608.31	60123.78	71396.99	82670.20	105216.62	90185.67
An. Equip. Chg.	33645.94	8411.49	16822.97	19226.25	22831.18	26436.10	33645.94	28839.38
An. Maintenance	21000.00	5250.00	10500.00	12000.00	14250.00	16500.00	21000.00	14400.00
An. Insurance	3500.00	875.00	1750.00	2000.00	2375.00	2750.00	3500.00	1200.00
Annual Charge	58145.94	14536.49	29072.97	33226.25	39456.18	45686.10	58145.94	44439.38
Serv. hrs./yr.	1600	1600	1600	1600	1600	1600	1600	1200
Mach. charge/hr	36.34	9.09	18.17	20.77	24.66	28.55	36.34	37.03
Operator cost/hr	9.00	8.00	8.50	8.50	8.50	9.00	9.00	9.00
Total	45.34	17.09	26.67	29.27	33.16	37.55	45.34	46.03
Fuel,Fluids per prod. hour	8.00	4.00	6.00	7.50	7.50	8.50	8.50	7.00
Utilization	70%	80%	80%	80%	75%	75%	75%	60%
Fuel Cost/hr	5.60	3.20	4.80	6.00	5.63	6.38	6.38	4.20
Total Cost/hr	50.94	20.29	31.47	35.27	38.79	43.93	51.72	50.23

Basis for Hourly Equipment Charge Estimates

	Chipper #1 @ Tractor	Chipper #2 @ Trailer	Chipper #3 @ Tractor	Chipper #4 @ Truck	Chipper #5 @ Forw.	Chipper #6 @ Truck	Chipper #7 @ Forw.	Chipper #8
Equipment Cost	70000	82000	156000	190000	225000	230000	260000	310000
Residual Value	25%	25%	25%	25%	25%	25%	20%	25%
Deprec. Life	5	5	5	5	5	5	5	5
Maint. % of Depr	100%	100%	100%	90%	100%	90%	100%	120%
Insurance Rate	2.5%	2.5%	2.5%	2.0%	2.5%	2.0%	2.5%	2.5%
Tax Rate	25%	25%	25%	25%	25%	25%	25%	25%
CCA	30%	30%	30%	30%	30%	30%	30%	30%
Financing								
Debt	75%	75%	75%	75%	75%	75%	75%	75%
Interest Rate	14%	14%	14%	14%	14%	14%	14%	14%
Equity	25%	25%	25%	25%	25%	25%	25%	25%
Return	30%	30%	30%	30%	30%	30%	30%	30%
Cost Cap.B.T.	18.00%	18.00%	18.00%	18.00%	18.00%	18.00%	18.00%	18.00%
A.T. Investment	59062.50	69187.50	131625.00	160312.50	189843.75	194062.50	219375.00	261562.50
PV Salvage A.T.	6454.19	7560.62	14383.63	17518.52	20745.61	21206.63	19178.17	28582.84
Net	52608.31	61626.88	117241.37	142793.98	169098.14	172855.87	200196.83	232979.66
An. Equip. Chg.	16822.97	19706.91	37491.19	45662.35	54073.84	55275.48	64018.51	74501.73
An. Maintenance	10500.00	12300.00	23400.00	25650.00	33750.00	31050.00	41600.00	55800.00
An. Insurance	1750.00	2050.00	3900.00	3800.00	5625.00	4600.00	6500.00	7750.00
Annual Charge	29072.97	34056.91	64791.19	75112.35	93448.84	90925.48	112118.51	138051.73
Serv. hrs./yr.	1600	1600	1600	1600	1600	1600	1600	1600
Mach. charge/hr	18.17	21.29	40.49	46.95	58.41	56.83	70.07	86.28
Operator cost/hr	8.50	8.50	8.50	9.00	9.00	9.50	9.50	10.00
Total	26.67	29.79	48.99	55.95	67.41	66.33	79.57	96.28
Fuel,Fluids per prod. hour	8.00	8.00	8.00	13.00	13.00	16.00	16.00	19.00
Utilization	70%	70%	75%	70%	75%	70%	75%	70%
Fuel Cost/hr	5.60	5.60	6.00	9.10	9.75	11.20	12.00	13.30
Total Cost/hr	32.27	35.39	54.99	65.05	77.16	77.53	91.57	109.58

Basis for Hourly Equipment Charge Estimates

	Small Dump Truck	Tractor & Dump Trail.	Log Truck	Tractor & L.B. Van	Truck&Trail. 6 Containers	Tractor & W.T. Trail.	Truck & W.T. Trailer
Equipment Cost	70000	120000	110000	150000	170000	140000	160000
Residual Value	25%	25%	25%	25%	25%	25%	25%
Deprec. Life	5	5	5	5	5	5	5
Maint. % of Depr	70%	70%	70%	70%	70%	70%	70%
Insurance Rate	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%
Tax Rate	25%	25%	25%	25%	25%	25%	25%
CCA	30%	30%	30%	30%	30%	30%	30%
Financing							
Debt	75%	75%	75%	75%	75%	75%	75%
Interest Rate	14%	14%	14%	14%	14%	14%	14%
Equity	25%	25%	25%	25%	25%	25%	25%
Return	30%	30%	30%	30%	30%	30%	30%
Cost Cap.B.T.	18.00%	18.00%	18.00%	18.00%	18.00%	18.00%	18.00%
A.T. Investment	39062.50	101250.00	92812.50	126562.50	143437.50	118125.00	135000.00
PV Salvage A.T.	6454.19	11064.33	10142.30	13830.41	15674.46	12908.38	14752.44
Net	52608.31	90185.67	82670.20	112732.09	127763.04	105216.62	120247.56
An. Equip. Chg.	16822.97	28839.38	26436.10	36049.22	40855.79	33645.94	38452.51
An. Maintenance	7350.00	12600.00	11550.00	15750.00	17850.00	14700.00	16800.00
An. Insurance	700.00	1200.00	1100.00	1500.00	1700.00	1400.00	1600.00
Annual Charge	24872.97	42639.38	39086.10	53299.22	60405.79	49745.94	56852.51
Serv. hrs./yr.	1600	1600	1600	1600	1600	1600	1600
Mach. charge/hr	15.55	26.65	24.43	33.31	37.75	31.09	35.53
Operator cost/hr	8.50	9.00	9.00	9.50	9.50	9.50	9.50
Total	24.05	35.65	33.43	42.81	47.25	40.59	45.03
Fuel,Fluids per prod. hour	8.00	10.00	10.00	10.50	11.00	12.00	14.00
Utilization	90%	90%	90%	90%	90%	80%	80%
Fuel Cost/hr	7.20	9.00	9.00	9.45	9.90	9.60	11.20
Total Cost/hr	31.25	44.65	42.43	52.26	57.15	50.19	56.23

(1) Fuel costs for trucks are based on unit idling for 30% of operating time during loading and unloading.

Relative Trucking Cost Estimates For Chips Based on Standard Rates.

Chipper Production(ODt/hr)	6	Chipper Utilization	70%
Avg. Haul Speed(km/hr)	60	Annual Prod. Shifts	200
Hours per Shift	8	Annual Production(ODt)	6720

	Small Dump Trucks	Dump Trailers	Live Bot. Chip Vans	Cont. Truck & Trailer
Truck Volume (Odt)	3.5	7	13.5	12
Hourly Rate	31	45	52	57
Availability	90%	90%	90%	90%
Loading Time	35	70	135	25
Unloading Time	5	10	15	50
One Way Haul(km)		Trucking Cost/ODt		
5				
Round Trip Time	50	90	160	85
Trucks Required	1.1	1.0	0.9	0.6
Cost per Tonne	7.38	9.64	10.27	6.73
10				
Round Trip Time	60	100	170	95
Trucks Required	1.3	1.1	1.0	0.6
Cost per Tonne	8.86	10.71	10.91	7.52
20				
Round Trip Time	80	120	190	115
Trucks Required	1.8	1.3	1.1	0.7
Cost per Tonne	11.81	12.86	12.20	9.10
30				
Round Trip Time	100	140	210	135
Trucks Required	2.2	1.6	1.2	0.9
Cost per Tonne	14.76	15.00	13.48	10.69
40				
Round Trip Time	120	160	230	155
Trucks Required	2.7	1.8	1.3	1.0
Cost per Tonne	17.71	17.14	14.77	12.27
50				
Round Trip Time	140	180	250	175
Trucks Required	3.1	2.0	1.4	1.1
Cost per Tonne	20.67	19.29	16.05	13.85
60				
Round Trip Time	160	200	270	195
Trucks Required	3.6	2.2	1.6	1.3
Cost per Tonne	23.62	21.43	17.33	15.44

Note: Fractional truck requirements can be either rounded up to provide excess truck capacity or rounded down to provide excess chipper capacity.

Relative Trucking Cost Estimates For Chips Based on Standard Rates.

Chipper Production(ODt/hr)	8	Chipper Utilization	70%
Avg. Haul Speed(km/hr)	60	Annual Prod. Shifts	200
Hours per Shift	8	Annual Production(ODt)	8960

	Small Dump Trucks	Dump Trailers	Live Bot. Chip Vans	Cont. Truck & Trailer
Truck Volume (Odt)	3.5	7	13.5	12
Hourly Rate	31	45	52	57
Availability	90%	90%	90%	90%
Loading Time	26.25	52.5	101.25	25
Unloading Time	5	10	15	50
One Way Haul(km)		Trucking Cost/ODt		
5				
Round Trip Time	41	73	126	85
Trucks Required	1.2	1.1	1.0	0.7
Cost per Tonne	6.09	7.77	8.10	6.73
10				
Round Trip Time	51	83	136	95
Trucks Required	1.5	1.2	1.0	0.8
Cost per Tonne	7.57	8.84	8.75	7.52
20				
Round Trip Time	71	103	156	115
Trucks Required	2.1	1.5	1.2	1.0
Cost per Tonne	10.52	10.98	10.03	9.10
30				
Round Trip Time	91	123	176	135
Trucks Required	2.7	1.8	1.4	1.2
Cost per Tonne	13.47	13.13	11.31	10.69
40				
Round Trip Time	111	143	196	155
Trucks Required	3.3	2.1	1.5	1.3
Cost per Tonne	16.42	15.27	12.60	12.27
50				
Round Trip Time	131	163	216	175
Trucks Required	3.9	2.4	1.7	1.5
Cost per Tonne	19.38	17.41	13.88	13.85
60				
Round Trip Time	151	183	236	195
Trucks Required	4.5	2.7	1.8	1.7
Cost per Tonne	22.33	19.55	15.17	15.44

Note: Fractional truck requirements can be either rounded up to provide excess truck capacity or rounded down to provide excess chipper capacity.

Relative Trucking Cost Estimates For Chips Based on Standard Rates.

Chipper Production(ODt/hr)	12	Chipper Utilization	70%
Avg. Haul Speed(km/hr)	60	Annual Prod. Shifts	200
Hours per Shift	8	Annual Production(ODt)	13440

	Small Dump Trucks	Dump Trailers	Live Bot. Chip Vans	Cont. Truck & Trailer
Truck Volume (Odt)	3.5	7	13.5	12
Hourly Rate	31	45	52	57
Availability	90%	90%	90%	90%
Loading Time	18	50	96	25
Unloading Time	5	10	15	50
One Way Haul(km)		Trucking Cost/ODt		
5				
Round Trip Time	33	70	121	95
Trucks Required	1.4	1.6	1.4	1.1
Cost per Tonne	4.80	7.50	7.80	6.73
10				
Round Trip Time	43	80	131	95
Trucks Required	1.9	1.8	1.5	1.2
Cost per Tonne	6.27	8.57	8.44	7.52
20				
Round Trip Time	63	100	151	115
Trucks Required	2.8	2.2	1.7	1.5
Cost per Tonne	9.23	10.71	9.72	9.10
30				
Round Trip Time	83	120	171	135
Trucks Required	3.7	2.7	2.0	1.8
Cost per Tonne	12.18	12.86	11.01	10.69
40				
Round Trip Time	103	140	191	155
Trucks Required	4.6	3.1	2.2	2.0
Cost per Tonne	15.13	15.00	12.29	12.27
50				
Round Trip Time	123	160	211	175
Trucks Required	5.4	3.6	2.4	2.3
Cost per Tonne	18.08	17.14	13.57	13.85
60				
Round Trip Time	143	180	231	195
Trucks Required	6.3	4.0	2.7	2.5
Cost per Tonne	21.04	19.29	14.86	15.44

Note: Fractional truck requirements can be either rounded up to provide excess truck capacity or rounded down to provide excess chipper capacity.

Estimated Costs - Chip Contractor #1

Waste Plant

- cull softwood purchased and delivered for chipping - market value $30/OD tonne plus $10/OD tonne delivery
- chipper rented at $110/day plus $6/hour for fuel, maintenance and delivery
- chip delivery in containers at $32/4 OD tonne container
- two workers at $8/hr and $7/hr for 8 hours
- daily production of 1.8 OD tonnes/hr with Eeger Beever or Carthage chipper for 8 hours
- estimated costs per OD tonnes:

Raw materials	$30
Delivery	10
Chipping	19
Delivery	8
	$67

Residential

- chips produced from cull softwood material at roadside and blown into truck
- chipper rented at $88/day plus $50/day for tractor and $6/hour for fuel, maintenance and transport
- daily production of 1.8 OD tonnes/hour with Bruks 722 chipper for 8 hours
- two workers at $8/hr and $7/hr for 8 hours
- chip delivery in 3 OD tonne modified bulk potato truck at $30/hr for 2 hours travel plus unloading
- estimated costs per OD tonne:

Raw materials	$30
Chipping	21
Delivery	20
	$71

- screening of chips would be additional

Estimated Costs - Chip Contractor #2

Slabs

- slabs purchased from local sawmill at $24/OD tonne delivered
- chipper rented at $110/day plus $6/hr for fuel, maintenance and delivery
- daily production of 1.4 OD tonnes/hr with Carthage chipper for 8 hours
- two workers at $8 and $7/hr for 8 hours
- $10/OD tonne for storage and handling
- chip delivery in 2.5 OD tonne loads in modified side dumping fertilizer truck at $30/hr for 3/4 hour loading and delivery.
- estimated costs per OD tonne:

Raw materials	$24
Chipping	25
Storage and Handling	10
Delivery	10
Total	$69

Pulpwood

- cull softwood purchased at $30/OD tonne
- pulpwood delivered with log truck @ $40/hr x 1.5 hrs/7.5 ODt load.
- daily production of 1.8 OD tonnes/hr with Eeger Beever chipper for 8 hours at rates above for chipper and labour.
- storage handling and delivery as above
- estimated costs per OD tonne:

Raw materials	$30
Delivery	8
Chipping	19
Storage and Handling	10
Delivery	10
Total	$77

Estimated Costs - Chip Contractor #3

Slabs

- raw materials are slabs produced by contractor's mill with an estimated value of $10/ODt for fuelwood.
- chipper rented at $110/day plus $6/hr for fuel, maintenance and delivery
- daily production of 1.4 OD tonnes/hr with Carthage chipper for 8 hours
- two workers at $8/hr and $7/hr for 8 hours
- chip delivery under contract with container service at $20/OD tonne
- estimated costs per OD tonne:

Raw materials	$10
Chipping	25
Delivery	20
Total	$55

Pulpwood

- for chip production from cull softwood add $30/OD tonne for raw materials, $8/OD tonne for delivery and reduce chipping costs by $6/OD tonne.

Estimated Costs - Chip Contractor #4

- wood is harvested whole tree at $4.00/ODt for stumpage
- the operation used the following machinery in 1984; costs were estimated using standard costs for machines, fuel, maintenance and operator

	Cost/Hour
Feller Buncher	$51
Grapple Skidder	39
Cable Skidder	31
Treelan D80 Chipper/Loader	50
3.5 ODt dump truck	30
6.0 ODt dump trailer	44

- estimated costs per OD tonne with 30 Km haul, 10 ODt/hr chipping rate

	45 ODt/day
Stumpage	$4.00
Felling	9.00
Forwarding	12.00
Chipping	9.00
Trucking and Handling	11.00
	$45.00
	======
Cost/Green Tonne @ 45%	(24.75)

- trucking costs contracted per tonne @ 20 km average haul
- additional costs are involved in storing and delivery of chips to the customer
- costs for storage and handling are estimated at $4.00/ODt
- trucking costs contracted per tonne @ 5 km average haul.

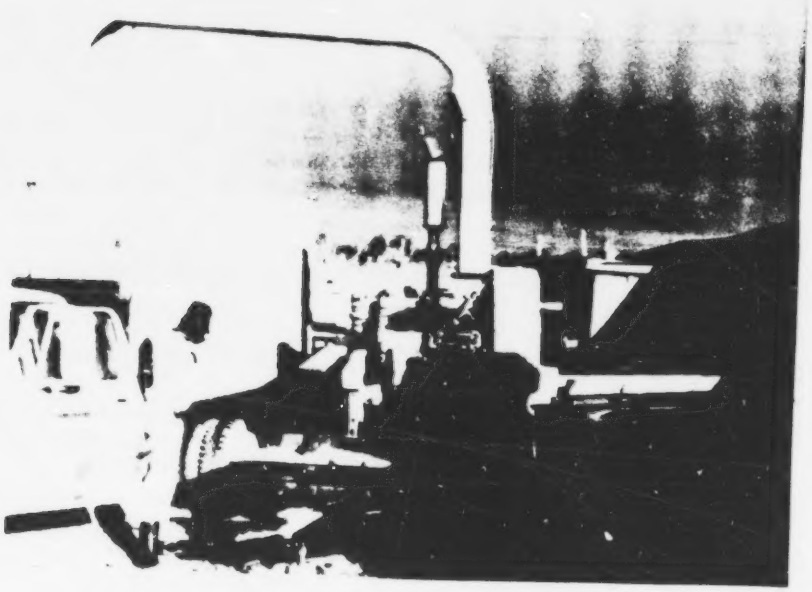


Figure A3.1. Chipping at a sawmill operation.

Figure A3.2. Mechanized Felling

Figure A3.3. Forwarding Whole Trees

Figure A3.4. Forwarding to a Cold Deck

Figure A3.5. Piling the Cold Deck

Figure A3.6 Integrated Chipping Using a Treelan D-60

APPENDIX 4

Testing The Tree Section System

Using Small Scale Equipment on P.E.I.

A 4.0 INTRODUCTION

The development of the wood chip market is seen as one way to develop a market for low grade wood from thinning operations. Significant production economies may be realized if the wood is extracted in whole tree form because delimbing is unnecessary and greater volumes of wood can be recovered from the stand. Scandinavian experience indicates that small scale recovery of wood from thinning operations can be most effective if done in tree sections which are easier to handle than whole trees (Andersson and Falk 1984, Hakkila et al 1978). Canadian experience in tree section thinning is limited.

The utilization of chips for fuel also requires significant amounts of storage. Where fuel chips are to be stored for extended periods, experience on P.E.I. indicates that covered storage is required (IEA, 1983). The cost of covered storage plus the additional cost of carrying processed chips as inventory can add significantly to overall costs. One possible way of reducing the above costs is to transport and store wood in its unprocessed form. This system can be beneficial if the additional costs of transporting and handling the wood are less than the storage and working capital costs of storing chips. Canadian experience in whole tree or tree section trucking is also limited.

This project was carried out to demonstrate the above systems using conventional equipment on Prince Edward Island.

A 4.1 Objectives

The objectives of the tree section demonstration were:

1. To demonstrate the tree section thinning system on a softwood stand using equipment readily available on P.E.I.

2. To demonstrate tree section transport of softwood from a thinning operation using available transportation equipment.

The demonstration was carried out on a single stand over a short period of time. The demonstration was intended to indicate the potential feasibility of the system rather than to evaluate the long-term productivity and applicability for all stand types.

A 4.2 The Site

The thinning site was a 1.2 ha (2.9 acre) block of a natural larch (Larix Laricina) stand located near Wellington, P.E.I. The stand was located in a demonstration woodlot of the P.E.I. Department of Energy and Forestry. The site layout is given in Figure A4.1. The stand was approximately 32 years old and was divided into 2 sections. The front section was thinned to 2 m x 2 m (6' x 6') spacing in 1983. The rear section was not previously thinned. Table A4.1 summarizes the biomass cruise volumes for the two stands before and after thinning. Photographs of the two stands before thinning are included in Figures A4.1 and A4.3.

A 4.3 The Thinning Operations

The front stand was thinned first. The total area thinned was 1 ha (2.4 acres); however, strip roads spaced 20 m (1 chain) apart had already been cut. The total stand area was therefore reduced to approximately 0.8 ha (2 acres). Two cutters worked

FIGURE A4.1. LAYOUT OF TREE SECTION THINNING OPERATION

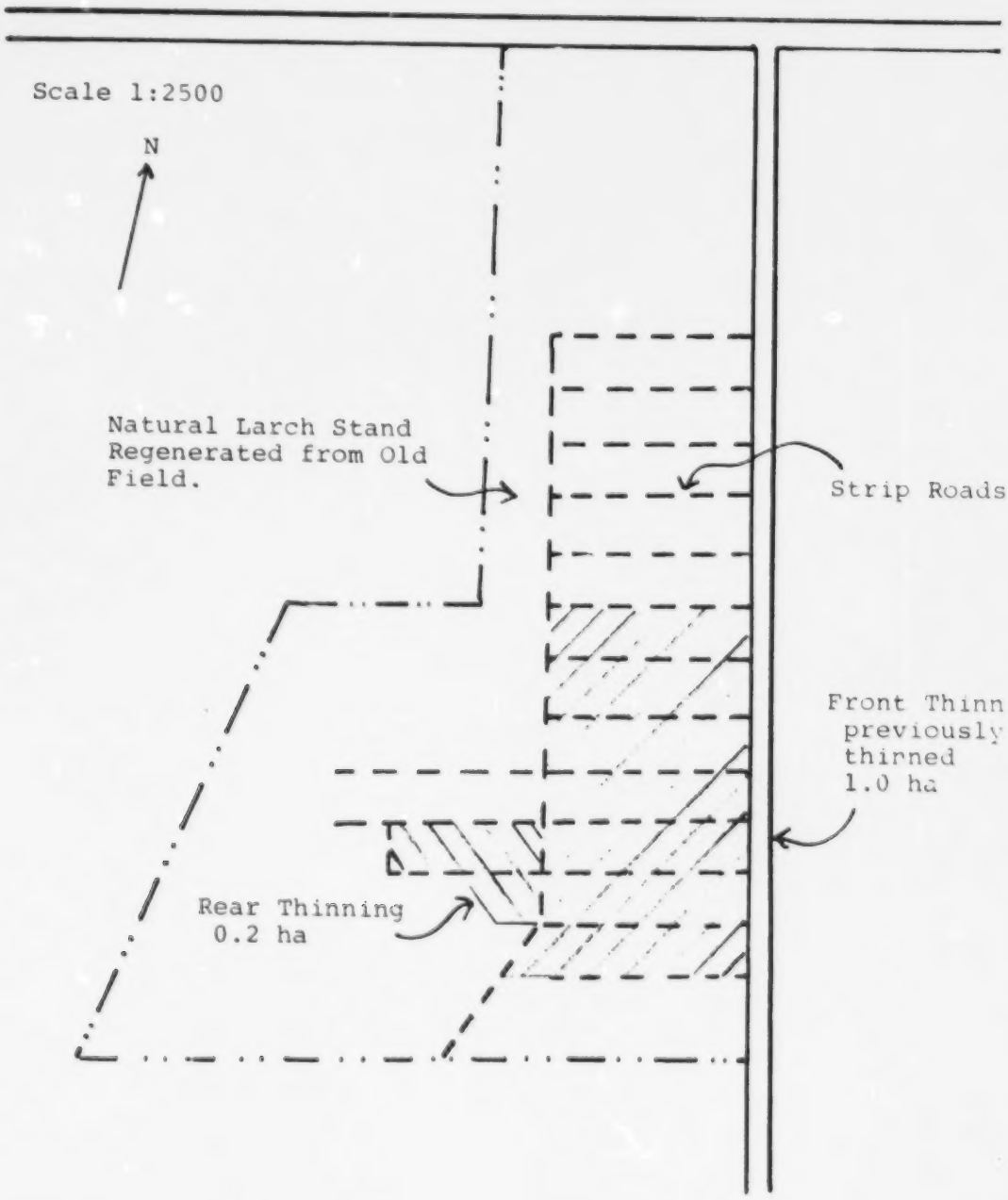


TABLE A4.1 BIOMASS CRUISE VOLUMES FOR STANDS

Diameter Class (cm)	Stems /ha	Before Thinning Harvestable OD tonnes/ha	Stems[1] /ha	After Thinning[1] Harvestable OD tonnes/ha
		Front, Previously Thinned Stand		
6	707	-	-	-
10	255	5.5	127	2.7
12	177	5.9	265	8.7
14	650	30.3	455	21.1
16	597	37.5	298	18.7
18	157	12.9	39	3.3
20	-	-	64	6.5
	2542	91.8	1249	61.1
		Rear Natural Stand		
10	764	14.9	127	2.7
12	354	11.5	265	8.7
14	520	24.3	455	21.1
16	398	25.0	298	18.7
18	314	25.0	39	3.3
20	-	-	64	6.5
22	105	13.3	-	-
	2455	114.0	1249	61.1

[1] Based on cruise plots in combined stand.

from the back of the stand to the front felling trees in a herring bone pattern. The trees were bucked in two or three 5 m (16') sections and moved manually into bundles as much as possible. A whole tree forwarding trial was attempted; however, the method was abandoned because of the residual damage and the difficulty of bucking the trees at roadside.

The forwarding operation was made up of a farm tractor with a Farmi Winch, a tractor operator and a chokerman with two sets of chokers. Tree section bundles were winched to the skid trail and forwarded to roadside where they were unloaded and compacted using the tractor. Photographs of the forwarding operation are included in Figures A4.5 to A4.8.

The rear stand was thinned using exactly the same system. The unthinned stand was much denser and more difficult to cut; however, volume production per unit area was also much greater. The operation was terminated early because of the extreme difficulty in feeding the wood by hand to the only suitable chipper available. Approximately 0.2 ha (0.5 acres) of the rear stand was thinned.

The costs for the thinning operation are included in Tables A4.2 and A4.3. The cutters were provided by the P.E.I. Department of Energy and Forestry on whose land the work was done. The wages for the cutters were estimated at $7.00/hr plus $1.50/hr for the saw. Man hours varied daily because of other commitments. Costs for the winching operation are based on $15/hr for the tractor and winch, $8.00/hr. for the operator and $7.00/hr for the chokerman. All wage costs include fringe benefits. Half days have been combined.

TABLE A4.2 COSTS OF CUTTING OPERATION

Date	Man Hours	Labour Cost	Saw Cost	Total Cost
	Front, Previously Thinned Stand			
Aug. 28	8.0	$ 56.00	$12.00	$ 68.00
29	15.5	108.50	23.25	131.75
30	10.5	73.50	15.75	89.25
Sept 3,4	8.0	56.00	12.00	68.00
TOTAL	42.0	$294.00	$63.00	$357.00
Estimated Production				16 OD tonnes
Cost				$ 22.31/OD tonne
	Rear, Natural Stand			
Sept 4	6.5	$ 45.50	$ 9.75	$ 55.25
12,13	17.0	119.00	25.50	144.50
14	6.5	45.50	9.75	55.25
TOTAL	30.0	$210.00	$45.00	$255.00
Estimated Production				8.1 OD tonnes
Cost				$31.48/OD tonne

TABLE A4.3 COSTS OF THE WINCHING OPERATION

Date	Man Hours	Productive Tractor Hrs	Total Tractor Hours	Labour Cost	Machine Cost	Total Cost
		Front, Previously Thinned Stand				
Aug 28	9	4	5	$ 67.50	$ 75.00	$142.50
29	14	6	6	105.00	90.00	195.00
30	10	5	6	75.00	90.00	165.00
Sept 3,4	12.5	6	6	45.00	90.00	135.00
TOTAL	45.5	21	23	$292.50	$345.00	$637.50
Estimated Production						16 OD tonnes
Cost						$39.84/OD tonne
		Rear, Natural Stand				
Sept. 12,13	18	9	9	$135.00	$135.00	$270.00
Sept. 14	13	6.5	6.5	97.50	97.50	195.00
	31	15.5	15.5	$232.50	$232.50	$465.00
Estimated Production						8.1 OD tonnes
Cost						$57.40/OD tonne

A 4.4 The Trucking Operation

Trucking was carried out using a standard logging truck with 6 m (20') deck, 2.5 m (8') high stakes and a loader mounted on the back of the cab. The truck was loaded and the load trimmed to expose the tail lights and to remove overhanging branches. The first three loads were weighed and the remainder estimated because the scales were not operating. Load weights are summarized in Table A4.4. The last three loads were the most evenly compacted indicating that the load estimates may be conservative; however, the wood was also drier and smaller in size.

Photographs of full tree trucking are included in Figures A4.9 and A4.10. The photographs are of the first load. Later loads were more uniform as bucking and piling at roadside became more consistent.

The average haul distance was 18 km (11 miles); however, the truck had to travel from the local sawmill which added 12 km to the trip. The loads were trucked on different days as a result of the tight scheduling of the truck. The trucking fee was estimated at $50/load based on 15 minutes for loading, 45 minutes travel time and 15 minutes for unloading at $40/hr. The trucking cost averaged $12.45/OD tonne ($11.32/OD ton).

Additional costs resulting from long waits at the weigh scale and hiring the truck to move wood at the storage facility were not included in the above figures. These costs would not be incurred in an actual operation. The trucking operation averaged

TABLE A4.4 ESTIMATED LOAD WEIGHTS

Load	Net Tons	OD Tonnes
	Front, Previously Thinned Stand	
1	8.9	4.0
2	7.9	3.6
3	9.4	4.3
4	9.0[1]	4.1[1]
TOTAL	35.2	16.0
	Rear, Natural Stand	
5	8.0[1]	4.1[1]
6	8.0[1]	4.1[1]
TOTAL	16.0	8.1
OVERALL TOTAL	51.2	24.1

[1] Estimated

TABLE 4.5. PRODUCTION SUMMARY

Stand	Estimated Volume Removed Based On Cruise	Estimated Harvest	Difference
Front	24.6 ODt	16.0 ODt	54%
Rear	10.6	8.1	31%
Total	35.2 ODt	24.1 ODt	46%

4.02 OD tonnes per load. Based on an average load volume of 36.2 cu.m[1] (1280 cu.ft.), the average bulk density of the load was 111 OD Kg/cu.m (6.9 OD lbs/cu.ft.). The highest bulk density achieved was 119 kg/cu.m (7.44.6 lbs/cu.ft.).

A 4.5 Chipping

The only chipper which was available which could chip limby material was a small Bruks 722 chipper mounted on a 50HP tractor. The chipper was manually fed by two or three men. The chipper worked well; however, the additional manpower was required to pull trees out of the tangled pile of tree sections. Productivity of 1 OD tonne per hour at a cost of $47/hr for the chipper, tractor and 3 operators resulted in chipping costs in excess of $45/OD tonne.

There is presently only one chipper, a Treelan D60, on the Island that is suitable for commercial production of chips. It was not available at the time or economical for a project of this size.

A 4.6 Moisture Content

Samples were taken of the chips produced from both operations. The moisture contents are summarized in Table A4.6.

1 6 m x 2.4 m x 2.4 m (20' x 8' x 8') Effective truck volume

TABLE A4.6 SUMMARY OF CHIP MOISTURE CONTENTS (WET BASIS)

Date	Thinning	Number Samples	Mean M.C.	St. Dev.	Range
Sept. 10	Front	6	50.7%	1.79	48.3-53.1%
11	Front	5	49.3%	2.92	44.6-53.3%
27,28	Rear	3	44.2%	4.41	38.0-47.6%

Both stands were chipped approximately two weeks after felling. The rear stand had a higher proportion of dead material and small trees which may account for the lower average moisture content.

A 4.7 Discussion

The costs of the operation are summarized in Table A4.7.

TABLE A4.7 RECORDED COSTS OF CHIP PRODUCTION FROM TREE SECTIONS

	Per Oven Dry Tonne	
Component	Front Thinning	Rear Thinning
Cutting	$22.31	$31.48
Forwarding	39.84	57.40
Trucking	12.45	12.45
Chipping	50.00	50.00
TOTAL	$124.60	$151.33

The overall cost of the chips was high, primarily because the chipper was not suitable for commercial production and the stand was a thinning operation.

In the future, more productive chippers should be used for this type of operation. For example, a large truck mounted chipper could be contracted to chip the entire 24.1 OD tonnes in three or four hours at an estimated cost of $15/ODt. A silvicultural incentive of up to $410/ha could also be applied to thinnings where harvested wood is utilized. Table A4.8 outlines the adjusted chip costs based on the above assumptions. The table indicates that the cost of producing chips from the front thinning operation was significantly lower than the price of oil. The adjusted cost of the rear thinning operation remained relatively high when compared with the equivalent price of oil. This sample was based on a very small plot where the crew did not have time to become experienced in handling the dense wood and underbrush.

TABLE A4.8 ADJUSTED COSTS OF CHIP PRODUCTION

	Per Oven Dry Tonne	
Component	Front Thinning	Rear Thinning
Cutting	$22.31	$31.48
Forwarding	39.84	57.40
Trucking	12.45	12.45
SUBTOTAL	$74.60	101.33
Full Incentive	20.50	10.12
	$54.10	$91.21
Chipping	15.00	15.00
Total	$69.10	$106.21
Equivalent Oil Value[1]	$139.40	$139.40

1 Based on wood at 50% M.C., 70% furnace efficiency; oil at $0.32/L, 80% furnace efficiency.

Significant cost reductions could be expected in future operations. The crew had never carried out an operation of this type and were therefore not expected to be operating at peak productivity during the one week operation. The forwarding operation was also limited because only one set of chokers was available during the first day and the operator had to work alone on the last day of the operation. Wood harvested from the strip roads, which would have been the lowest cost wood, had already been harvested.

The trucking operation achieved a maximum load density of approximately 119 OD kg/cu.m. (7.4 OD lbs/cu.ft). Other studies indicate that a wide variation in load weight can be expected depending on tree species and other conditions. Assuming an average green moisture content of 50%, Lavoie (1980) achieved densities of approximately 190 OD kg/cu.m. (12 OD lbs/cu.ft) trucking balsam fir and 135 OD kg/cu.m (8.5 OD lbs/cu.ft) trucking spruce. Both trials were conducted during the summer using whole tree pulpwood in Quebec. The trucking operation was based on conventional 3m x 3m x 12m (load volume) pulp trailers loaded with tops to the rear for the bottom half of the load and tops to the front for the top half of the load. Densities may be over estimated because considerable amounts of overhang were allowed. Similar results were obtained by Routhier (1982). The Coban Institute achieved densities of approximately 80-90 OD Kg/cu.m (5-5.5 OD lbs/cu.ft) trucking mature aspen with conventional pulp trailers during the winter in Alberta. In summary, research indicates that softwoods can be trucked whole

tree at load densities slightly lower than or comparable to chips. Hardwoods with large branches will have much lower bulk densities.

Overall, an operator should be able to improve cutting and forwarding productivity up to 50% with experience. Improved trucking efficiencies using a 12 m pulp trailer or a truck and trailer with sides should reduce transport costs by 30%. A counteracting cost factor would be that full silvicultural incentives may not be provided for the operation. Table A4.9 outlines the chip production costs that may be achieved based on the above assumptions.

TABLE A4.9. ESTIMATED ACHIEVEABLE CHIP PRODUCTION COSTS BASED ON FRONT THINNING RESULTS

Component	Per Oven Dry Tonne
Cutting	$15.00
Forwarding	27.00
Trucking	9.00
Subtotal	$51.00
50% Incentive	10.00
	41.00
Chipping	15.00
Total	$56.00

A4.8 Summary

Tree section thinning for chip production can be a productive method for utilizing low grade softwoods. Chips could be produced for fuel at a significant savings relative to the price of oil if a productive chipper is utilized for processing.

Whole tree trucking of softwood thinnings can achieve load densities slightly lower than that of wood chips. For practical, economical trucking, large volume trailers or truck/trailer combinations with sides should be utilized.

Figure A4.1 Larch stand previously thinned to 2m x 2m spacin

Figure A4.2 Above stand after tree section thinning.

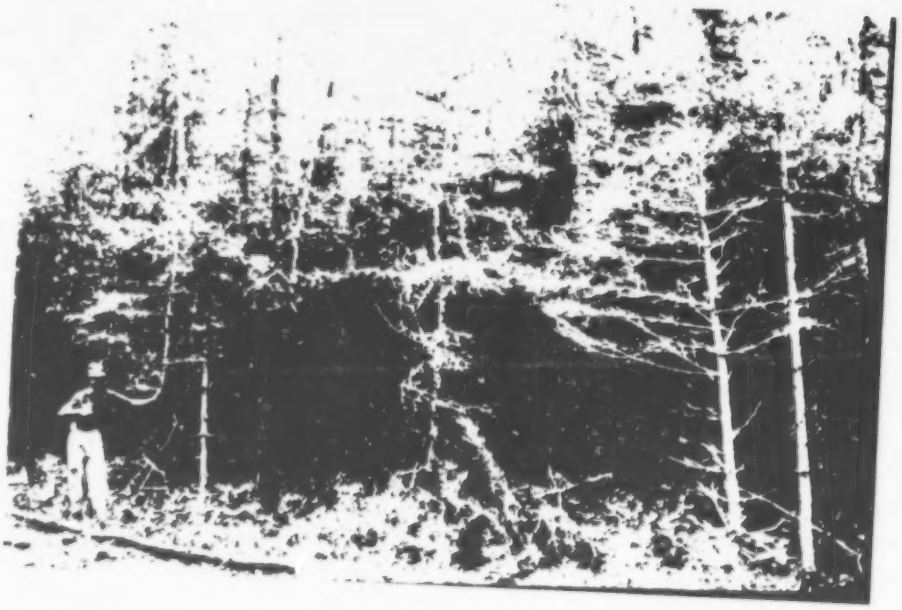


Figure A4.3 Natural larch stand before thinning.

Figure A4.4 Natural larch stand after thinning.

Figure A4.5 Winching of tree sections.

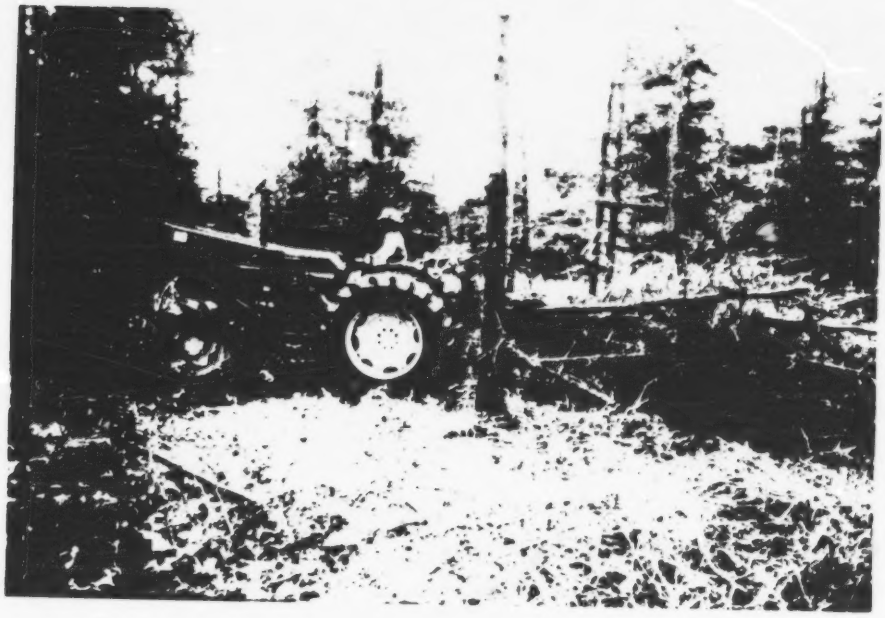


Figure A4.6 Forwarding of tree sections.

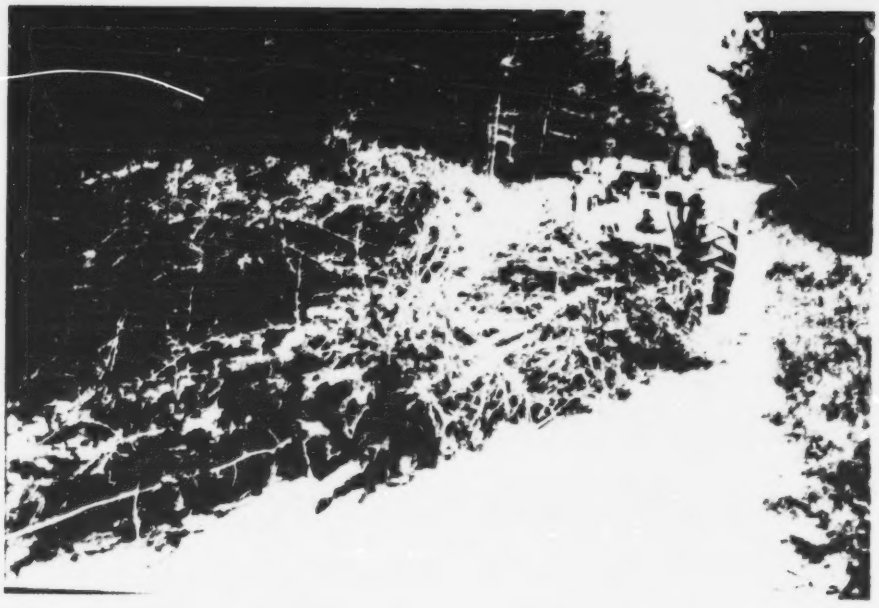


Figure A4.7 Unhooking load at roadside.

Figure A4.8. Compaction of tree sections at roadside.

Figure A4.9 Loading full trees on conventional stake truck.

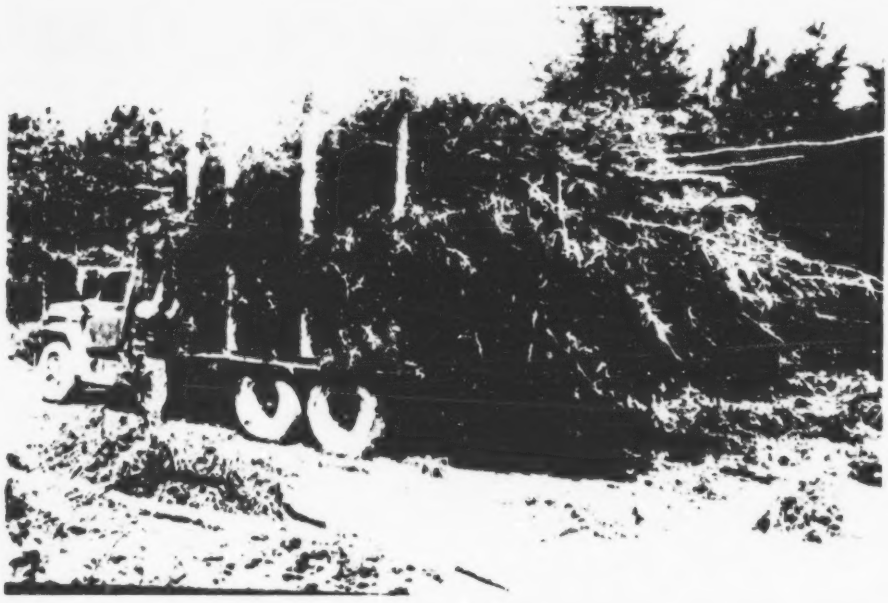


Figure A4.10 Trimming the full load. Pruning shears and a chainsaw were used.

APPENDIX 5

Financial Evaluation of Chip Production Modules

	Page
Sawmill Residue Business	1
Medium Contractor #1	5
Medium Contractor #2	9
Large Contractor	13
Wood Chip Terminal	17

Sawmill Residue Business

Assumptions

Capital Item	Gross Cost	Investment Incentive	Net Cost	Salvage Value	Useful Life(yrs)	Cap. Cost Allow.
Chipper	8000	50%	4000	25%	5	20%
Screen	8000	50%	4000	25%	5	20%
Blower	4000	50%	2000	25%	5	20%
Engine	7000	50%	3500	25%	5	20%
Storage	20000	40%	12000	0%	20	5%
Misc.	5000	50%	2500	0%	20	20%
TOTAL	52000		28000			

Initial D/C Ratio 75%

Corporate Tax Rate 25%

Financing	Security	Amount	Rate	Term(yrs)
Line of Credit	A/R, Inventory	9598	15%	Callable
Debt	Assets, Pers. Guar.	21000	14%	5
Gov't Grants	Assets, Pers. Guar.	24000	0%	Perform.
Equity	None	7000	35%	-

Labour Costs	Number Workers	Hourly Wage	Fringe Ben. %	Gross Wage	Man-hrs Per Tonne
Driver/Loader	1	8.41	7%	9.00	0.40

Operating Expenses	Annual Cost		Per Tonne	Per Kilometre
Fuel			4.00	0.25
Gen. & Admin.	5%	Yr 1 Sales		
Insurance	800			
Maintenance	1200		3.00	0.20
TOTAL	2000			

Production/Delivery

First Year Production (ODt) 475

Prod. Growth Rate 19%

Labour	ODt	Odt/Load	ODt/hr	Cost/ODt
Driver	475	2.5	3.3	2.73
Loader	475		10.00	0.90

Average Del. Dist. (km) 15

	Year 1	Year 2	Year 3	Year 4	Year 5
Sales (ODt)	475	565	672	799	950
Annual hrs (2000/yr)	191	228	271	322	383
Annual km	5700	6778	8061	9586	11400
Growth Factor	1.00	1.05	1.10	1.16	1.22

Sawmill Residue Business

Income Statement
For Year Ended

Price per ODt $43.75 Raw Mat. per ODt $12.00

	Year 1	Year 2	Year 3	Year 4	Year 5
Gross Sales	20781	25949	32402	40459	50520
Cost of Sales:					
Materials	5700	7117	8887	11097	13857
Wages	1723	2151	2686	3354	4188
Fuel	3325	4152	5184	6473	8083
Maintenance	2565	3203	3999	4994	6236
Delivery			Included		
Total	13313	16623	20757	25919	32364
Net Sales	7469	9326	11645	14541	18156
Operating Exp.:					
Gen. & Admin.	1039	1091	1146	1203	1263
Insurance	800	840	882	926	972
Depreciation	2750	2750	2750	2750	2750
Maintenance	1200	1260	1323	1389	1459
Total	5789	5941	6101	6268	6444
Operating Income	1679	3385	5544	8272	11712
Interest	4380	4104	3469	2444	1261
Earnings Before Tax	-2700	-719	2075	5829	10451
Income Tax	0	0	327	1385	4835
Net Income	-2700	-719	1748	4444	5616
Equity Inv. -7000					
Undeprec. Cap. Cost	28000	27950	25919	22402	25500 19362
Cash Flow B.T.	50	2031	4825	8579	13201
Cap. Cost Allow.	50	2031	3518	3040	-6138
Taxable Income	0	0	1308	5539	19340
Income Tax	0	0	327	1385	4835
Cash Flow ex. Princ.	50	2031	4498	7194	8366
Principal	3177	3622	4129	4707	5366
Net Cash -7000	-3127	-1591	370	2487	28501

Discounted Return 25.1%

Sawmill Residue Business

Balance Sheet
As Of End Of Year

Days Receivables	30	Days Inv.	15	Days Pay.	15

	Year 1	Year 2	Year 3	Year 4	Year 5
ASSETS					
Current Assets:					
Cash	5000	5000	5000	5000	5000
Acc't Rec.	1708	2133	2663	3325	4152
Inventory	547	683	853	1065	1330
Total	7255	7816	8516	9391	10482
Fixed Assets:					
Land	0	0	0	0	0
Equipment	28000	25250	22500	19750	17000
Deprec.	2750	2750	2750	2750	2750
Net	25250	22500	19750	17000	14250
Total	25250	22500	19750	17000	14250
TOTAL	32505	30316	28266	26391	24732
EQUITY					
Current Liabilities:					
Acc't Pay.	547	683	853	1065	1330
Line Credit	9598	10724	9871	6890	3398
Total	10145	11408	10724	7955	4728
Long Term Debt	18060	15328	12213	8662	4615
Owners Equity:					
Common Stock	7000	7000	7000	7000	7000
Ret. Earnings	-2700	-3419	-1671	2773	8390
Total	4300	3581	5329	9773	15390
TOTAL	32505	30316	28266	26391	24732

Sawmill Residue Business

First Year Cash Flow Statement

First Year Production (ODt): 475 Average Price per ODt: $43.75 Avg. Cost per ODt $28.03

	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	TOTAL
Percent Sales	5%	4%	5%	6%	8%	9%	11%	12%	12%	11%	9%	8%	100%
Sales (ODt)	24	19	24	29	38	43	52	57	57	52	43	38	475
Production (ODt)	70	70	70	60	50	40	30	8	8	8	26	35	475
Inventory (ODt)	46	97	144	175	187	184	162	113	64	20	3	0	
Gross Sales	1039	831	1039	1247	1663	1870	2286	2494	2494	2286	1870	1663	20781
Cost of Goods Produced:													
Materials	840	840	840	720	600	480	360	96	96	96	312	420	5700
Wages	254	254	254	218	181	145	109	29	29	29	94	127	1723
Fuel	490	490	490	420	350	280	210	56	56	56	182	245	3325
Maintenance	378	378	378	324	270	216	162	43	43	43	140	189	2565
Delivery	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	1962	1962	1962	1682	1401	1121	841	224	224	224	729	981	13313
Net Revenue	-923	-1131	-923	-435	261	749	1445	2270	2270	2062	1142	682	7469
Operating Expense:													
Gen. & Admin.	87	87	87	87	87	87	87	87	87	87	87	87	1039
Insurance	67	67	67	67	67	67	67	67	67	67	67	67	800
Maintenance	100	100	100	100	100	100	100	100	100	100	100	100	1200
Interest	365	365	365	365	365	365	365	365	365	365	365	365	4380
Principal	265	265	265	265	265	265	265	265	265	265	265	265	3177
Taxes	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	883	883	883	883	883	883	883	883	883	883	883	883	10596
Net Cash Flow	-1806	-2014	-1806	-1318	-622	-134	562	1387	1387	1179	259	-201	-3127
Cum. Cash Flow	-1806	-3819	-5625	-6943	-7565	-7698	-7136	-5750	-4363	-3184	-2926	-3127	

Medium Contractor No.1

Assumptions

Capital Item	Gross Cost	Investment Incentive	Net Cost	Salvage Value	Useful Life(yrs)	Cap. Cost Allow.
Chipper	82000	50%	41000	25%	5	30%
Dump Truck	70000	0%	70000	25%	5	30%
Loader	50000	50%	25000	25%	5	30%
Pole Barn	42000	40%	25200	0%	20	5%
Land	2000	0%	2000	0%		
Misc.	14000	50%	7000	0%	5	20%
TOTAL	260000		170200			

Initial D/C Ratio 75% Corporate Tax Rate 25%

Financing	Security	Amount	Rate	Term(yrs)
Line of Credit	A/R, Inventory	26021	15%	Callable
Debt	Assets, Pers. Guar.	127650	14%	5
Gov't Grants	Assets, Pers. Guar.	89800	0%	Perform.
Equity	None	42550	35%	-

Labour Costs	Number Workers	Hourly Wage	Fringe Ben. %	Gross Wage	Man-hrs Per Tonne
Chip/Driver/Loader	1	8.41	7%	9.00	0.57

Operating Expenses	Annual Cost	Per Tonne	Per Kilometre
Fuel		2.30	0.25
Gen. & Admin.	5% Yr 1 Sales		
Insurance	2600		
Maintenance	3000	2.75	0.20
TOTAL	5600		

Production/Delivery

First Year Production (ODt) 1750 Prod. Growth Rate 19%

Labour	ODt	Odt/Load	ODt/hr	Cost/ODt
Chipper	1750	3.5	4.2	2.14
Driver	2275	3.5	4.7	1.91
Loader	525		10.00	0.90

Average Del. Dist. (km) 13.5

	Year 1	Year 2	Year 3	Year 4	Year 5
Sales (ODt)	1750	2081	2475	2943	3500
Annual hrs (2000/yr)	1006	1196	1422	1691	2011
Annual km	17550	20871	24820	29516	35100
Growth Factor	1.00	1.05	1.10	1.16	1.22

Medium Contractor No.1

Income Statement
For Year Ended

Price per ODt	$60.75		Raw Mat. per ODt		$23.00
	Year 1	Year 2	Year 3	Year 4	Year 5
Gross Sales	106313	132749	165760	206980	258450
Cost of Sales:					
Materials	40250	50259	62757	78363	97849
Wages	9050	11301	14111	17620	22001
Fuel	8413	10504	13117	16378	20451
Maintenance	8323	10392	12976	16203	20232
Delivery			Included		
Total	66035	82456	102960	128564	160534
Net Sales	40277	50293	62800	78416	97916
Operating Exp.:					
Gen. & Admin.	5316	5581	5860	6154	6461
Insurance	2600	2730	2867	3010	3160
Depreciation	23060	23060	23060	23060	23060
Maintenance	3000	3150	3308	3473	3647
Total	33976	34521	35094	35696	36328
Operating Income	6302	15772	27705	42720	61588
Interest	21774	18898	13504	5993	-3410
Earnings Before Tax	-15472	-3126	14201	36727	64998
Income Tax	0	0	207	8164	23236
Net Income	-15472	-3126	13994	28562	41763
Equity Inv. -42550					84000
Undeprec. Cap. Cost	170200	162612	142678	106246	79116
Cash Flow B.T.	7588	19934	37261	59787	88058
Cap. Cost Allow.	7588	19934	36432	27130	-4884
Taxable Income	0	0	828	32657	92942
Income Tax	0	0	207	8164	23236
Cash Flow ex. Princ.	7588	19934	37054	51622	64823
Principal	19311	22015	25097	28611	32616
Net Cash -42550	-11724	-2081	11957	23012	116207
Discounted Return		25.2%			

Medium Contractor No.1

Balance Sheet
As Of End Of Year

Days Receivables 30 Days Inv. 15 Days Pay. 15

	Year 1	Year 2	Year 3	Year 4	Year 5
ASSETS					
Current Assets:					
Cash	5000	5000	5000	5000	5000
Acc't Rec.	8738	10911	13624	17012	21242
Inventory	2714	3389	4231	5283	6597
Total	16452	19300	22855	27295	32840
Fixed Assets:					
Land	2000	2000	2000	2000	2000
Equipment	170200	147140	124080	101020	77960
Deprec.	23060	23060	23060	23060	23060
Net	147140	124080	101020	77960	54900
Total	149140	126080	103020	79960	56900
TOTAL	165592	145380	125875	107255	89740
EQUITY					
Current Liabilities:					
Acc't Pay.	2714	3389	4231	5283	6597
Line Credit	26021	24868	9460	-17191	-53178
Total	28735	28256	13691	-11908	-46581
Long Term Debt	109779	93171	74238	52655	28050
Owners Equity:					
Common Stock	42550	42550	42550	42550	42550
Ret. Earnings	-15472	-18598	-4604	23958	65721
Total	27078	23952	37946	66508	108271
TOTAL	165592	145380	125875	107255	89740

Medium Contractor No.1

First Year Cash Flow Statement

First Year Production (ODt): 1750 Average Price per ODt: $60.75 Avg. Cost per ODt $37.73

	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	TOTAL
Percent Sales	5%	4%	5%	6%	8%	9%	11%	12%	12%	11%	9%	8%	100%
Sales (ODt)	88	70	88	105	140	158	193	210	210	193	158	140	1750
Production (ODt)	150	200	200	200	200	200	50	180	180	193	158	140	1750
Inventory (ODt)	63	193	305	400	460	503	360	330	300	218	100	0	
Gross Sales	5316	4253	5316	6379	8505	9568	11694	12758	12758	11694	9568	8505	106313
Cost of Goods Produced:													
Materials	3450	4600	4600	4600	4600	4600	1150	4140	4140	2530	920	920	40250
Wages	776	1034	1034	1034	1034	1034	259	931	931	569	207	207	9050
Fuel	721	961	961	961	961	961	240	865	865	529	192	192	8413
Maintenance	713	951	951	951	951	951	238	856	856	523	190	190	8323
Delivery	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	5660	7547	7547	7547	7547	7547	1887	6792	6792	4151	1509	1509	66035
Net Revenue	-345	-3294	-2231	-1168	958	2021	9808	5965	5965	7544	8059	6996	40277
Operating Expense:													
Gen. & Admin.	443	443	443	443	443	443	443	443	443	443	443	443	5316
Insurance	217	217	217	217	217	217	217	217	217	217	217	217	2600
Maintenance	250	250	250	250	250	250	250	250	250	250	250	250	3000
Interest	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	21774
Principal	1609	1609	1609	1609	1609	1609	1609	1609	1609	1609	1609	1609	19311
Taxes	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	4333	4333	4333	4333	4333	4333	4333	4333	4333	4333	4333	4333	52001
Net Cash Flow	-4678	-7628	-6565	-5502	-3375	-2312	5474	1632	1632	3210	3725	2662	-11724
Cum. Cash Flow	-4678	-12306	-18870	-24372	-27747	-30059	-24585	-22953	-21321	-18111	-14386	-11724	

Medium Contractor No.2

Assumptions

Capital Item	Gross Cost	Investment Incentive	Net Cost	Salvage Value	Useful Life(yrs)	Cap. Cost Allow.
Chipper	155000	50%	77500	25%	5	30%
Loader	50000	50%	25000	25%	5	30%
Bins	12000	50%	6000	25%	5	30%
Pole Barn	42000	40%	25200	0%	20	5%
Land	2000		2000			
Misc.	14000	50%	7000	0%	5	20%
TOTAL	275000		142700			

Initial D/C Ratio 75% Corporate Tax Rate 25%

Financing	Security	Amount	Rate	Term(yrs)
Line of Credit	A/R, Inventory	24768	15%	Callable
Debt	Assets, Pers. Guar.	107025	14%	5
Gov't Grants	Assets, Pers. Guar.	132300	0%	Perform.
Equity	None	35675	35%	-

Labour Costs	Number Workers	Hourly Wage	Fringe Ben. %	Gross Wage	Man-hrs Per Tonne
Chipper/Loader	1	8.41	7%	9.00	0.48

Operating Expenses	Annual Cost		Per Tonne	Per Kilometre
Fuel			3.50	0.00
Gen. & Admin.	4%	Yr 1 Sales		
Insurance	2500			
Maintenance	2900		7.00	0.00
TOTAL	5400			

Production/Delivery

First Year Production (ODt)	1750		Prod. Growth Rate		19%
Labour	ODt	Odt/Load		ODt/hr	Cost/ODt
Chipper	1750	2.5		2.4	3.75
Loader	525			10.00	0.90
Avg. Del. Dist. (km)	13.5	Rate/ODt	8.10	ODt/load	9.8

	Year 1	Year 2	Year 3	Year 4	Year 5
Sales (ODt)	1750	2081	2475	2943	3500
Annual hrs (2000/yr)	834	992	1180	1403	1668
Deliveries	232	276	328	390	464
Growth Factor	1.00	1.05	1.10	1.16	1.22

Medium Contractor No.2

Income Statement
For Year Ended

Price per ODt $55.25 Raw Mat. per ODt $11.00

	Year 1	Year 2	Year 3	Year 4	Year 5
Gross Sales	96688	120731	150753	188241	235051
Cost of Sales:					
Materials	19250	24037	30014	37478	46797
Wages	7506	9373	11704	14614	18248
Fuel	6125	7648	9550	11925	14890
Maintenance	12250	15296	19100	23850	29780
Delivery	18428	23010	28732	35876	44798
Total	63559	79364	99100	123743	154514
Net Sales	33129	41367	51653	64498	80537
Operating Exp.:					
Gen. & Admin.	3868	4061	4264	4477	4701
Insurance	2500	2625	2756	2894	3039
Depreciation	18935	18935	18935	18935	18935
Maintenance	2900	3045	3197	3357	3525
Total	28203	28666	29152	29663	30200
Operating Income	4926	12701	22501	34835	50337
Interest	18699	16555	12361	6398	-483
Earnings Before Tax	-13773	-3854	10140	28437	50820
Income Tax	0	0	0	6083	21791
Net Income	-13773	-3854	10140	22354	29029
Equity Inv. -35675					87750
Undeprec. Cap. Cost	142700	137538	122457	93381	70340
Cash Flow B.T.	5162	15081	29075	47372	69755
Cap. Cost Allow.	5162	15081	29075	23041	-17410
Taxable Income	0	0	0	24331	87165
Income Tax	0	0	0	6083	21791
Cash Flow ex. Princ.	5162	15081	29075	41289	47964
Principal	16191	18458	21042	23988	27346
Net Cash -35675	-11029	-3377	8033	17301	108368

Discounted Return 25.0%

Medium Contractor No.2

Balance Sheet
As Of End Of Year

Days Receivables	30	Days Inv.	15	Days Pay.	15
	Year 1	Year 2	Year 3	Year 4	Year 5
		ASSETS			
Current Assets:					
Cash	5000	5000	5000	5000	5000
Acc't Rec.	7947	9923	12391	15472	19319
Inventory	2612	3262	4073	5085	6350
Total	15559	18185	21463	25557	30669
Fixed Assets:					
Land	2000	2000	2000	2000	2000
Equipment	142700	123765	104830	85895	66960
Deprec.	18935	18935	18935	18935	18935
Net	123765	104830	85895	66960	48025
Total	125765	106830	87895	68960	50025
TOTAL	141324	125015	109358	94517	80694
		EQUITY			
Current Liabilities:					
Acc't Pay.	2612	3262	4073	5085	6350
Line Credit	24768	25588	14854	-5258	-28745
Total	27380	28849	18926	-173	-22395
Long Term Debt	92042	78117	62243	44147	23518
Owners Equity:					
Common Stock	35675	35675	35675	35675	35675
Ret. Earnings	-13773	-17627	-7486	14868	43897
Total	21902	18048	28189	50543	79572
TOTAL	141324	125015	109358	94517	80694

Medium Contractor No.2

First Year Cash Flow Statement

First Year Production (ODt): 1750 Average Price per ODt: $55.25 Avg. Cost per ODt $36.32

	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	TOTAL
Percent Sales	5%	4%	5%	6%	8%	9%	11%	12%	12%	11%	9%	8%	100%
Sales (ODt)	88	70	88	105	140	158	193	210	210	193	158	140	1750
Production (ODt)	150	200	200	200	200	200	50	180	180	110	40	40	1750
Inventory (ODt)	63	193	305	400	460	503	360	330	300	218	100	0	
Gross Sales	4834	3868	4834	5801	7735	8702	10636	11603	11603	10636	8702	7735	96688
Cost of Goods Produced:													
Materials	1650	2200	2200	2200	2200	2200	550	1980	1980	1210	440	440	19250
Wages	643	858	858	858	858	858	214	772	772	472	172	172	7506
Fuel	525	700	700	700	700	700	175	630	630	385	140	140	6125
Maintenance	1050	1400	1400	1400	1400	1400	350	1260	1260	770	280	280	12250
Delivery	1580	2106	2106	2106	2106	2106	527	1895	1895	1158	421	421	18428
Total	5448	7264	7264	7264	7264	7264	1816	6537	6537	3995	1453	1453	63559
Net Revenue	-614	-3396	-2430	-1463	471	1438	8820	5065	5065	6640	7249	6282	33129
Operating Expense:													
Gen. & Admin.	322	322	322	322	322	322	322	322	322	322	322	322	3868
Insurance	208	208	208	208	208	208	208	208	208	208	208	208	2500
Maintenance	242	242	242	242	242	242	242	242	242	242	242	242	2900
Interest	1558	1558	1558	1558	1558	1558	1558	1558	1558	1558	1558	1558	18699
Principal	1349	1349	1349	1349	1349	1349	1349	1349	1349	1349	1349	1349	16191
Taxes	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	3680	3680	3680	3680	3680	3680	3680	3680	3680	3680	3680	3680	44157
Net Cash Flow	-4293	-7076	-6109	-5142	-3209	-2242	5140	1385	1385	2961	3569	2602	-11029
Cum. Cash Flow	-4293	-11369	-17479	-22621	-25830	-28072	-22932	-21546	-20161	-17201	-13631	-11029	

Large Contractor

Assumptions

Capital Item	Gross Cost	Investment Incentive	Net Cost	Salvage Value	Useful Life(yrs)	Cap. Cost Allow.
Chipper	230000	50%	115000	25%	5	30%
Cont. System	170000	30%	119000	20%	5	30%
Loader	120000	50%	60000	25%	5	30%
Pole Barn	110000	40%	66000	0%	20	5%
Paving	10000	20%	8000	0%	20	8%
Land	5000	0%	5000	0%		
Misc.	20000	50%	10000	0%	5	20%
TOTAL	665000		383000			

Initial D/C Ratio 75%

Corporate Tax Rate 25%

Financing	Security	Amount	Rate	Term(yrs)
Line of Credit	A/R, Inventory	53806	15%	Callable
Debt	Assets, Pers. Guar.	287250	14%	5
Gov't Grants	Assets, Pers. Guar.	282000	0%	Perform.
Equity	None	95750		-

Labour Costs	Number Workers	Hourly Wage	Fringe Ben. %	Gross Wage	Man-hrs Per Tonne
Chipper	1	8.41	7%	9.00	694
Driver/Loader	1	8.41	7%	9.00	1233

Operating Expenses	Annual Cost		Per Tonne	Per Kilometre
Fuel			2.40	0.25
Gen. & Admin.	3%	Yr 1 Sales		
Insurance	3000			
Maintenance	5000		4.00	0.40
TOTAL	8000			

Production/Delivery

First Year Production (ODt) 5000 Prod. Growth Rate 19%

Labour	ODt	Odt/Load	ODt/hr	Cost/ODt
Chipper	5000		7.2	1.25
Driver	6500	9.8 avg.	6.0	1.50
Loader	1500		20.00	0.45

Average Del. Dist. (km) 25

	Year 1	Year 2	Year 3	Year 4	Year 5
Sales (ODt)	5000	5946	7071	8409	10000
Annual hrs (2000/yr)	1928	2293	2726	3242	3856
Annual km	33163	39438	46900	55774	66327
Growth Factor	1.00	1.05	1.10	1.16	1.22

Large Contractor

Income Statement
For Year Ended

Price per ODt	$53.75		Raw Mat. per ODt		$23.00
	Year 1	Year 2	Year 3	Year 4	Year 5
Gross Sales	268750	335580	419029	523229	653341
Cost of Sales:					
Materials	115000	143597	179305	223893	279569
Wages	17347	21661	27048	33774	42172
Fuel	20291	25337	31637	39504	49328
Maintenance	33265	41537	51867	64764	30869
Delivery			Included		
Total	185904	232132	289857	361936	451938
Net Sales	82846	103448	129172	161294	201403
Operating Exp.:					
Gen. & Admin.	8063	8466	8889	9333	9800
Insurance	3000	3150	3308	3473	3647
Depreciation	50990	50990	50990	50990	50990
Maintenance	5000	5250	5513	5788	6078
Total	67053	67856	68699	69584	70514
Operating Income	15794	35592	60473	91709	130888
Interest	48286	41935	30344	14344	-4423
Earnings Before Tax	-32492	-6342	30129	77365	135311
Income Tax	0	0	625	17265	55215
Net Income	-32492	-6342	29504	60100	80096
Equity Inv. -95750					216500
Undeprec. Cap. Cost	383000	364502	319855	241235	181941
Cash Flow B.T.	18498	44648	81119	128355	186301
Cap. Cost Allow.	18498	44648	78619	59295	-34559
Taxable Income	0	0	2500	69060	220860
Income Tax	0	0	625	17265	55215
Cash Flow ex. Princ.	18498	44648	80494	111090	131086
Principal	43456	49540	56476	64382	73396
Net Cash -95750	-24958	-4893	24018	46708	274190
Discounted Return		25.6%			

Large Contractor

Balance Sheet
As Of End Of Year

Days Receivables	30	Days Inv.	15	Days Pay.	15

	Year 1	Year 2	Year 3	Year 4	Year 5
		ASSETS			
Current Assets:					
Cash	5000	5000	5000	5000	5000
Acc't Rec.	22089	27582	34441	43005	53699
Inventory	7640	9540	11912	14874	18573
Total	34729	42122	51353	62879	77272
Fixed Assets:					
Land	5000	5000	5000	5000	5000
Equipment	383000	332010	281020	230030	179040
Deprec.	50990	50990	50990	50990	50990
Net	332010	281020	230030	179040	128050
Total	337010	286020	235030	184040	133050
TOTAL	371739	328142	286383	246919	210322
		EQUITY			
Current Liabilities:					
Acc't Pay.	7640	9540	11912	14874	18573
Line Credit	53806	52024	20993	-32963	-97986
Total	61446	61563	32905	-18089	-79413
Long Term Debt	247035	209663	167058	118489	63120
Owners Equity:					
Common Stock	95750	95750	95750	95750	95750
Ret. Earnings	-32492	-38835	-9331	50769	130865
Total	63258	56915	86419	146519	226615
TOTAL	371739	328142	286383	246919	210322

Large Contractor

First Year Cash Flow Statement

First Year Production (ODt): 5000 Average Price per ODt: $53.75 Avg. Cost per ODt $37.18

	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	TOTAL
Percent Sales	5%	4%	5%	6%	8%	9%	11%	12%	12%	11%	9%	8%	100%
Sales (ODt)	250	200	250	300	400	450	550	600	600	550	450	400	5000
Production (ODt)	300	600	700	800	800	600	100	400	400	100	100	100	5000
Inventory (ODt)	50	450	900	1400	1800	1950	1500	1300	1100	650	300	0	
Gross Sales	13438	10750	13438	16125	21500	24188	29563	32250	32250	29563	24188	21500	268750
Cost of Goods Produced:													
Materials	6900	13800	16100	18400	18400	13800	2300	9200	9200	2300	2300	2300	115000
Wages	1041	2082	2429	2776	2776	2082	347	1388	1388	347	347	347	17347
Fuel	1217	2435	2841	3247	3247	2435	406	1623	1623	406	406	406	20291
Maintenance	1996	3992	4657	5322	5322	3992	665	2661	2661	665	665	665	33265
Delivery	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	11154	22308	26027	29745	29745	22308	3718	14872	14872	3718	3718	3718	185904
Net Revenue	2283	-11558	-12589	-13620	-8245	1879	25844	17378	17378	25844	20469	17782	82946
Operating Expense:													
Gen. & Admin.	672	672	672	672	672	672	672	672	672	672	672	672	8063
Insurance	250	250	250	250	250	250	250	250	250	250	250	250	3000
Maintenance	417	417	417	417	417	417	417	417	417	417	417	417	5000
Interest	4024	4024	4024	4024	4024	4024	4024	4024	4024	4024	4024	4024	48286
Principal	3621	3621	3621	3621	3621	3621	3621	3621	3621	3621	3621	3621	43456
Taxes	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	8984	8984	8984	8984	8984	8984	8984	8984	8984	8984	8984	8984	107805
Net Cash Flow	-6700	-20542	-21573	-22603	-17228	-7105	16861	8394	8394	16861	11486	8798	-24958
Cum. Cash Flow	-6700	-27243	-48815	-71419	-88647	-95752	-78891	-70497	-62103	-45242	-33756	-24958	

Wood Chip Terminal

Assumptions

Capital Item	Gross Cost	Investment Incentive	Net Cost	Salvage Value	Useful Life(yrs)	Cap. Cost Allow.
Trucks	810000	0%	810000	15%	5	30%
Loaders	240000	40%	144000	15%	5	30%
Chipper	100000	40%	60000	15%	5	20%
Screen	100000	40%	60000	15%	5	20%
Handling	90000	40%	54000	15%	5	20%
Truck Scale	150000	40%	90000	0%	10	20%
Storage	250000	40%	150000	0%	20	5%
Office	30000	40%	18000	0%	20	5%
Paving	300000	20%	240000	0%	20	8%
Land	100000		100000			
Misc.	150000	40%	90000	0%	5	20%
TOTAL	2320000		1816000			

Initial D/C Ratio 75%

Corporate Tax Rate 25%
And 45%

Financing	Security	Amount	Rate	Term(yrs)
Line of Credit	A/R, Inventory	305095	15%	Callable
Debt	Assets, Pers. Guar.	1362000	14%	5
Gov't Grants	Assets, Pers. Guar.	504000	0%	Perform.
Equity	None	454000		-

Labour Costs	Number Workers	Hourly Wage	Fringe Ben. %	Gross Wage	Man-hrs Per Tonne
Loader Operators	2	8.88	7%	9.50	0.05
Drivers	6	8.41	7%	9.00	0.42
Chipper Operator	1	8.88	7%	9.50	0.05

Operating Expenses	Annual Cost		Fuel	Maint
Trucks		per km	0.25	0.35
Loaders		per ODt	0.50	0.50
Chipping System		per ODt	1.50	1.00
Gen. & Admin.	4%	Yr 1 Sales		
Insurance	20000			
Maintenance	40000			
TOTAL	60000			

Wood Chip Terminal

Production/Delivery

First Year Production (ODt)		30000	Prod. Growth Rate		7%
Labour	ODt	Odt/Load		ODt/hr	Cost/ODt
Wood Transport	30000	10.5		4.0	2.25
Chipping System	30000			20.0	0.48
Loader	30000	20	ODt/hr	20.0	2.11
Chip Delivery	30000	7		6.0	1.50
Average Del. Dist. (km)		Wood	30	Chips	8

	Year 1	Year 2	Year 3	Year 4	Year 5
Sales (ODt)	30000	32237	34641	37224	40000
Annual hrs (2000/yr)					
Loaders	1500	1612	1732	1861	2000
Operator	1500	1612	1732	1861	2000
Drivers	12500	13432	14434	15510	16667
Annual km					
Wood	171429	184212	197949	212710	228571
Chips	68571	73685	79179	85084	91429
Growth Factor	1.00	1.05	1.10	1.16	1.22

Wood Chip Terminal

Income Statement
For Year Ended

Price per ODt $52.60 Raw Mat. per ODt $22.00

	Year 1	Year 2	Year 3	Year 4	Year 5
Gross Sales	1578000	1780455	2008885	2266622	2557426
Cost of Sales:					
Materials	660000	744677	840218	948017	1069646
Wages	141000	151514	162813	174954	188000
Fuel	120000	128948	138564	148897	160000
Maintenance	129000	138620	148956	160064	172000
Delivery			Included		
Total	1050000	1163759	1290551	1431931	1589646
Net Sales	528000	616696	718334	834690	967780
Operating Exp.:					
Gen. & Admin.	63120	66276	69590	73069	76723
Insurance	20000	21000	22050	23153	24310
Depreciation	239160	239160	239160	239160	239160
Maintenance	40000	42000	44100	46305	48620
Total	362280	368436	374900	381687	388813
Operating Income	165720	248260	343434	453004	578967
Interest	236444	193251	132931	60689	-22200
Earnings Before Tax	-70724	55009	210503	392314	601167
Income Tax	0	0	40759	142497	279718
Net Income	-70724	55009	169744	249817	321449
Equity Inv. -454000					711000
Undeprec. Cap. Cost	1816000	1647564	1353395	1066768	840843
Cash Flow B.T.	168436	294169	449663	631474	840327
Cap. Cost Allow.	168436	294169	286628	225924	129843
Taxable Income	0	0	163035	405550	710484
Income Tax	0	0	40759	142497	279718
Cash Flow ex. Princ.	168436	294169	408904	488977	560609
Principal	206048	234895	267780	305269	348007
Net Cash -454000	-37612	59274	141124	183707	923602

Discounted Return 25.2%

Wood Chip Terminal

Balance Sheet
As Of End Of Year

Days Receivables	30	Days Inv.	30	Days Pay.	15

	Year 1	Year 2	Year 3	Year 4	Year 5
		ASSETS			
Current Assets:					
Cash	10000	10000	10000	10000	10000
Acc't Rec.	129699	146339	165114	186298	210199
Inventory	86301	95651	106073	117693	130656
Total	226000	251990	281187	313991	350855
Fixed Assets:					
Land	100000	100000	100000	100000	100000
Equipment	1816000	1576840	1337680	1098520	859360
Deprec.	239160	239160	239160	239160	239160
Net	1576840	1337680	1098520	859360	620200
Total	1676840	1437680	1198520	959360	720200
TOTAL	1902840	1689670	1479707	1273351	1071055
		EQUITY			
Current Liabilities:					
Acc't Pay.	43151	47826	53036	58846	65328
Line Credit	305095	209441	26532	-205160	-472954
Total	348244	257267	79569	-146313	-407526
Long Term Debt	1171320	994119	792109	561818	299286
Owners Equity:					
Common Stock	454000	454000	454000	454000	454000
Ret. Earnings	-70724	-15715	154029	403846	725295
Total	383276	438285	608029	857846	1179295
TOTAL	1902840	1689670	1479707	1273351	1071055

Wood Chip Terminal

First Year Cash Flow Statement

First Year Production (ODt): 30000 Average Price per ODt: $53.10 Avg. Cost per ODt $36.00

	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	TOTAL
Percent Sales	5%	4%	5%	6%	8%	9%	11%	12%	12%	11%	9%	8%	100%
Sales (ODt)	1500	1200	1500	1800	2400	2700	3300	3600	3600	3300	2700	2400	30000
Production (ODt)	1500	1500	2500	3000	3000	3000	2000	4200	4200	2000	1100	2000	30000
Inventory (ODt)	0	300	1300	2500	3100	3400	2100	2700	3300	2000	400	0	
Gross Sales	79650	63720	79650	95580	127440	143370	175230	191160	191160	175230	143370	127440	1593000
Cost of Goods Produced:													
Materials	34500	34500	57500	69000	69000	69000	46000	96600	96600	46000	25300	46000	690000
Wages	7050	7050	11750	14100	14100	14100	9400	19740	19740	9400	5170	9400	141000
Fuel	6000	6000	10000	12000	12000	12000	8000	16800	16800	8000	4400	8000	120000
Maintenance	6450	6450	10750	12900	12900	12900	8600	18060	18060	8600	4730	8600	129000
Delivery	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	54000	54000	90000	108000	108000	108000	72000	151200	151200	72000	39600	72000	1080000
Net Revenue	25650	9720	-10350	-12420	19440	35370	103230	39960	39960	103230	103770	55440	513000
Operating Expense:													
Gen. & Admin.	5310	5310	5310	5310	5310	5310	5310	5310	5310	5310	5310	5310	63720
Insurance	1667	1667	1667	1667	1667	1667	1667	1667	1667	1667	1667	1667	20000
Maintenance	3333	3333	3333	3333	3333	3333	3333	3333	3333	3333	3333	3333	40000
Interest	19969	19969	19969	19969	19969	19969	19969	19969	19969	19969	19969	19969	239632
Principal	17171	17171	17171	17171	17171	17171	17171	17171	17171	17171	17171	17171	206048
Taxes	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	47450	47450	47450	47450	47450	47450	47450	47450	47450	47450	47450	47450	569400
Net Cash Flow	-21800	-37730	-57800	-59870	-28010	-12080	55780	-7490	-7490	55780	56320	7990	-56400

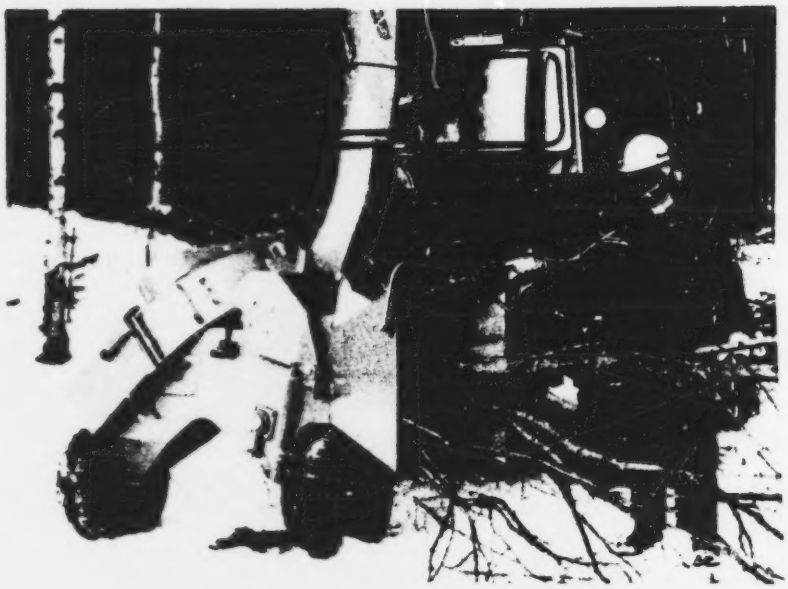
APPENDIX 6

Descriptions of Typical Models of Chipping and Chip Delivery Equipment

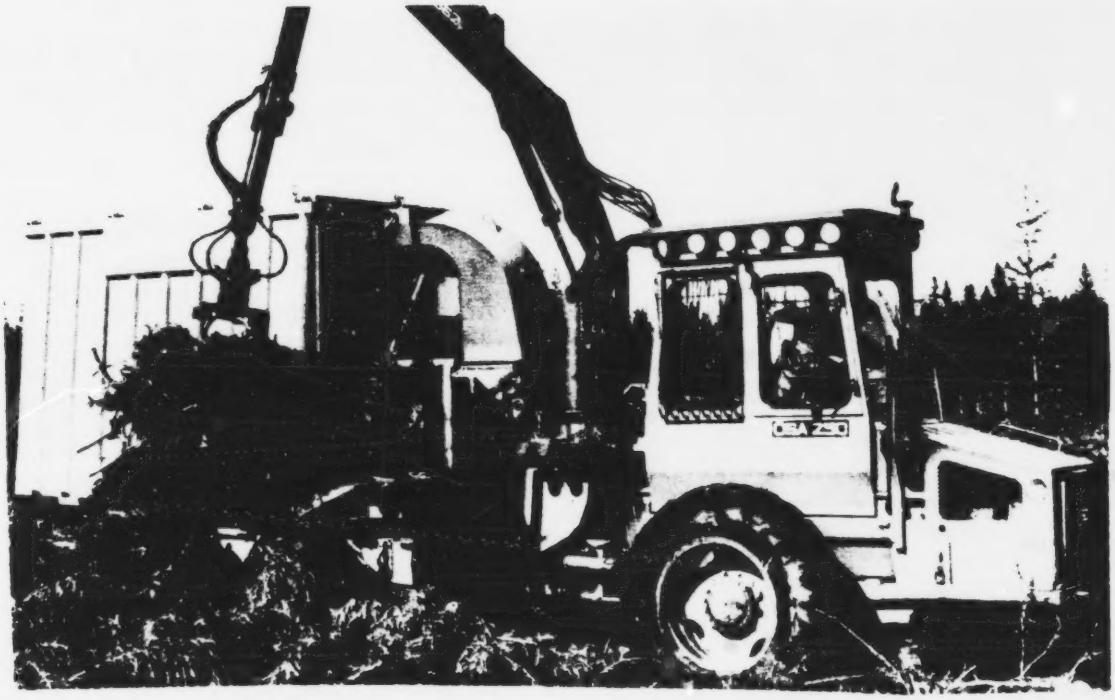
	Page
Chippers	1
Live Bottom Vans	11
Container Trucks	15
Dump Trailers	17

Note: The attached sheets include representative types of equipment discussed in this report. The list is not intended to be complete and inclusion does not mean that the equipment is recommended or the most suitable for any given purpose. Specifications are adapted from information provided by suppliers.

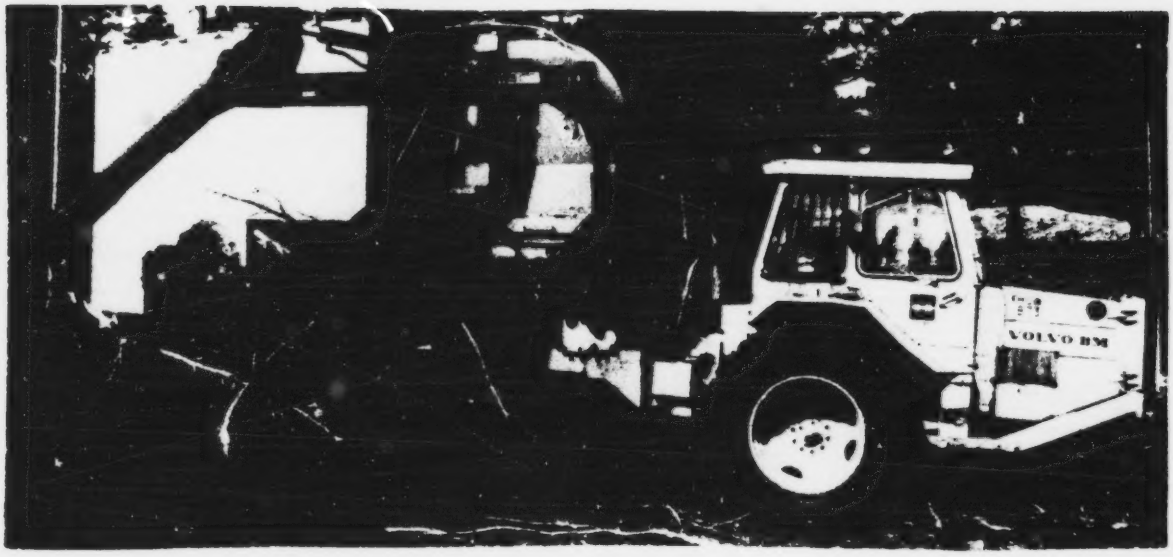
Photographs are printed with permission from the suppliers.



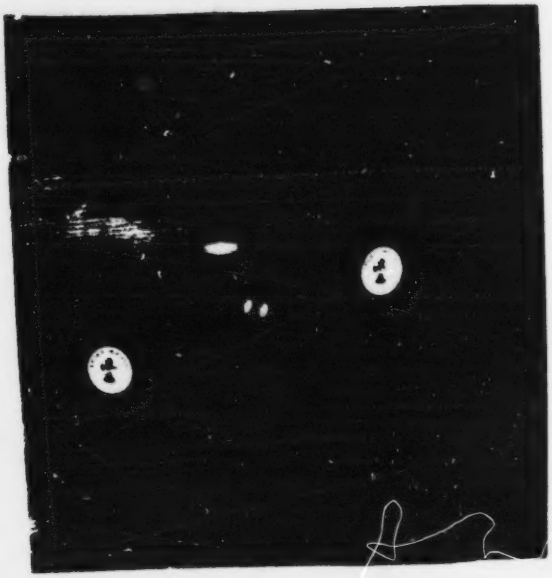
Chipper:	BRUKS 982 MT
Supplier:	BDR Machinery Ltd., Mississauga, Ontario
Description:	980 mm (39") disk chipper on single axle trailer, powered by a tractor PTO shaft
Dimensions:	1.5m W x 2.4m H x 2.75m L (5' x 8' x 9') when setup for transport
	1700 kg (3740 lbs.)
Capacity:	23 cm (9") maximum diameter
	4 ODt per hour
Features:	Two hydraulic infeed rollers
	2 or 4 knife chipping disk
	Requires 70-130 HP drive unit
	Manually fed
Price:	$24,000 complete
	$30,000 for larger 1300 (10 tonne per hour production)
Comments:	The 1300 model is presently used in Newcastle, New Brunswick, for chipping slabs and roundwood. Productivity is approximately 6-7 tonnes per hour.



Chipper:	Bruks 800 CT
Supplier:	BDR Machinery Ltd, Mississauga, Ontario
Description:	800 mm (32") drum chipper with power unit and chip bin
Dimensions:	Approx. 2.5m W x 3.8m H x 9.7m L (8' x 12.5' x 32') mounted on conventional forwarder Dump height approximately 3.2m (10.5') 4900 Kg (1078 lbs) for chipharvesting unit 30 cm (12") maximum diameter 5-8 OD tonnes per hour
Features:	Two hydraulic infeed rollers Two knife chipping drum 208 HP diesel engine Optional chain infeed chute 14 cu.m. side dumping chip bin holds approx. 2.5 ODt Adaptable for forwarder, truck or trailer mounting
Price:	$115,000 F.O.B. Chipping unit and bin $220,000 mounted on Timberjack 230 with grapple $100,000 for chipping unit without bin

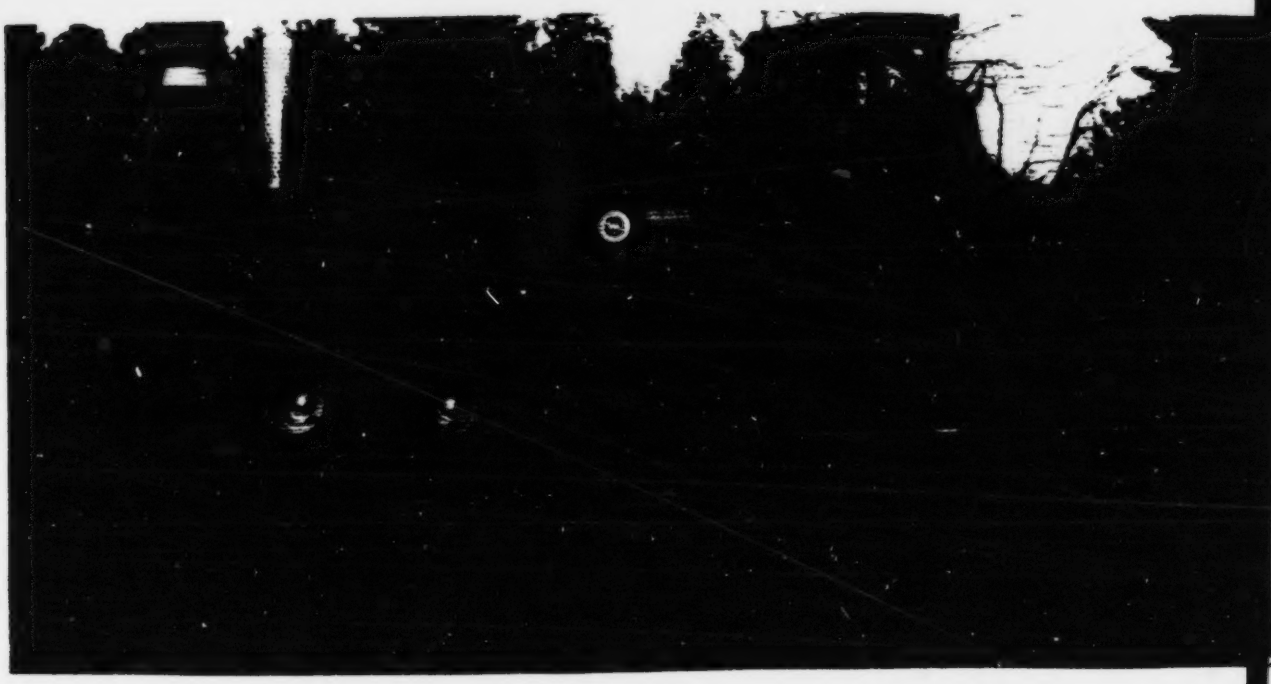


Chipper:	Bruks 1001 CT
Supplier:	BDR Machinery Ltd., Mississauga, Ontario
Description:	1000 mm (39") drum chipper with power unit and chip bin
Dimensions:	Approx. 2.4m W x 2.6m H x 6.4m L (8' x 8.5' x 21') for chipping unit
	Dump height approx. 3.6m (11.8') on forwarder
	9080 Kg (19980 lbs) for chip harvesting unit
Capacity:	40mm (16") maximum diameter, 15-20 tonnes per hour
Features:	Two hydraulic infeed rollers and chain infeed chute
	2 knife chipping drum, 275 HP diesel engine
	18 cu.m. side dumping chip bin holds approx. 3 ODt
	Adaptable for forwarder, truck or trailer mounting
Price:	$150,000 F.O.B. Halifax for Chipping Unit and Bin
	$135,000 for Chipping Unit without Bin
Comments:	The photograph above is the previous Model 1000. The unit is presently mounted on used Kockums Boogie Axle Forwarders at NSFI in Nova Scotia and Boise Cascade in New Brunswick. Total capital cost on rebuilt Kockums forwarder is approximately $250,000.

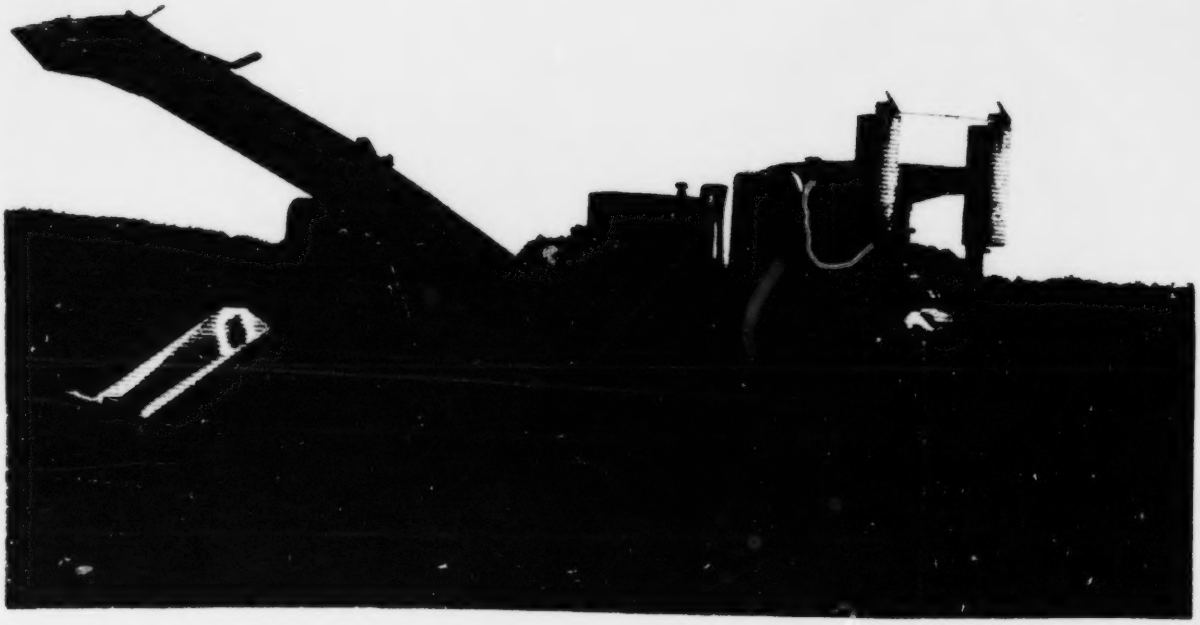


Chipper:	Eager Beever
Supplier:	Morbark Industries, North Bay, Ontario
Description:	950 mm (37 1/2") disk chipper with power unit on single axle trailer
Dimensions:	2.4 m W x 2.5 m H x 3.4 m H (8' x 8' x 11') with 0.9 m (36") spout
	1360 kg (3000 lbs)
Capacity:	2.5 cm (10") maximum diameter
	2-3 ODt per hour
Features:	Two hydraulic infeed rollers
	2 - 1/2 knife chipping disk
	60 HP gasoline engine
	Rear or curb side feed options
	Optional knuckle loader with 2.5m (8') reach
Price:	$16,000 with rear feed
Comments:	The unit is not practical for large trees with branches. A curb feed model is presently available in P.E.I.

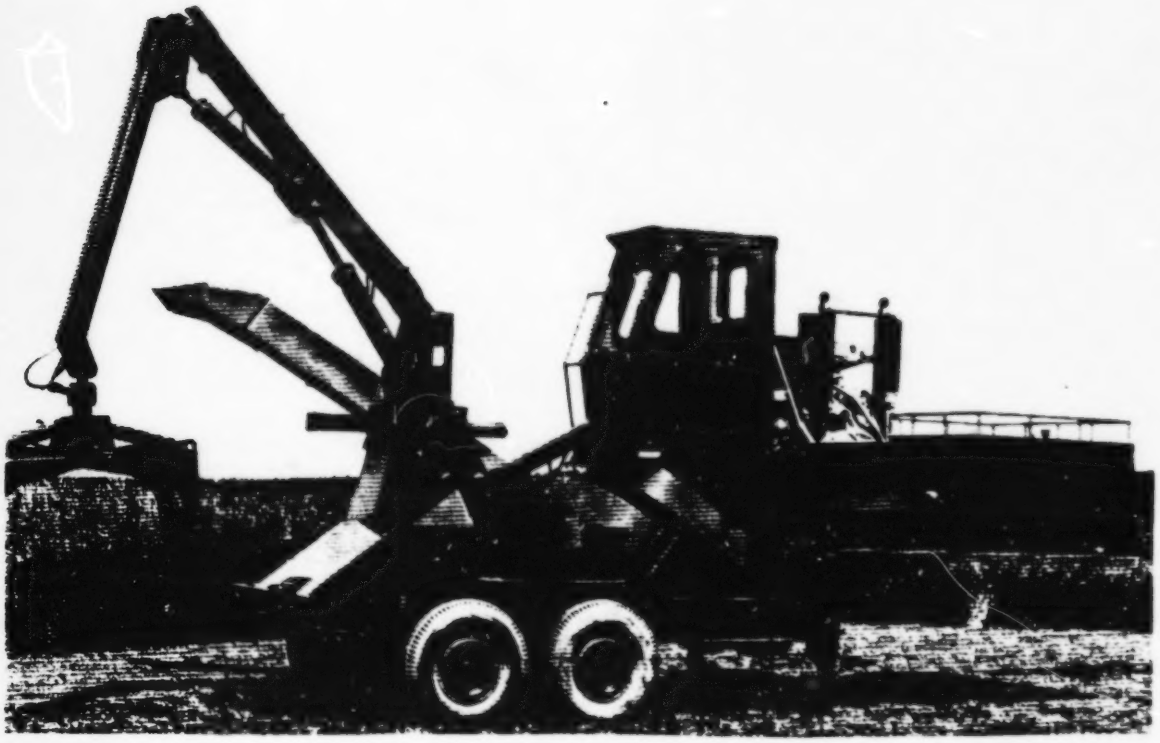
Chipper:	Super Beever
Supplier:	Morbark Industries, North Bay, Ontario
Description:	1220 mm (48") disk chipper with power unit on double axle trailer
Dimensions:	2.4 m W x 2.7 m H x 4.3 m L (8' x 9' x 14') (estimated)
	3600 kg (8000 lbs)
Capacity:	40cm (16") maximum diameter
	5-7 ODt per hour
Features:	Three hydraulic infeed rollers
	3 - 1/2 knife chipping disk
	250 HP engine
	Knuckle boom loader with 3.6 m (12') reach
Price:	$80,000 F.O.B. New Brunswick



Chipper:	Model 20 Total Chiparvester
Supplier:	Morbark Industries, North Bay, Ontario
Description:	1470 mm (58") disk chipper with power unit on double axle trailer
Dimensions:	2.7 m W x 4.1 m H x 75 m L (9 x 13.1' x 24.5')
	14500 kg (32000 lbs)
Capacity:	50 cm (20") maximum diameter
	9-14 ODt per hour (normal)
	2-2.5 ODt chips per gallon of fuel
Features:	Four hydraulic infeed rollers
	Two knife chipping disc
	350 HP diesel engine
	Knuckle boom loader with 3 m (10') reach
	Elevated, enclosed, all weather cab
Price:	$175,000 F.O.B. New Brunswick with spare parts kit, cab heater

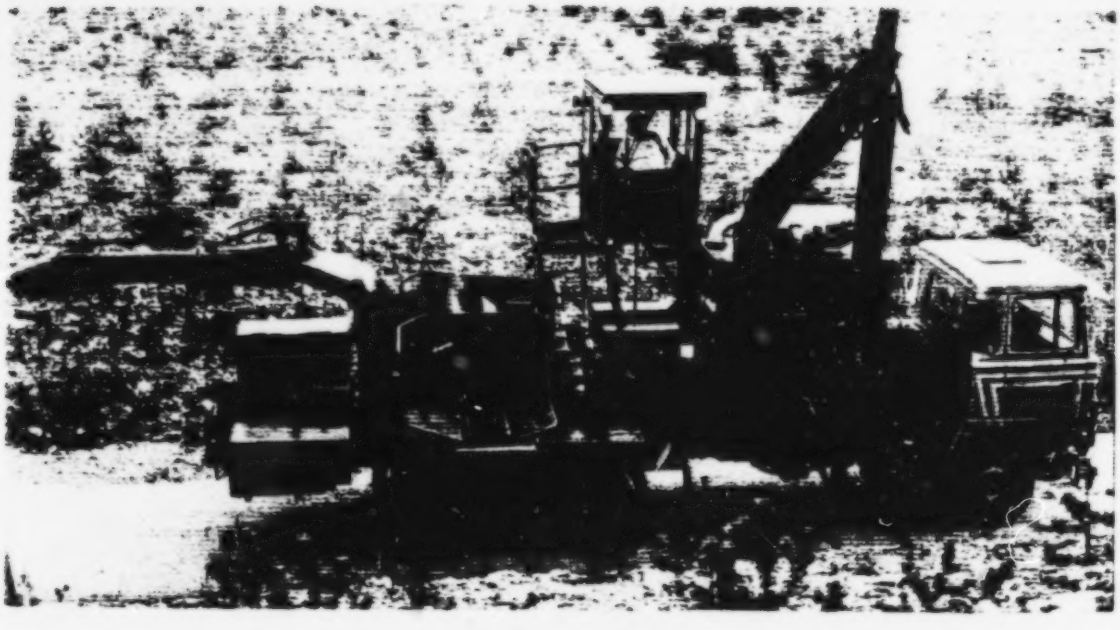


Chipper:	TREELAN D-60
Supplier:	Atmus Equipment Ltd., Truro, Nova Scotia.
Description:	1520 mm (60") disk chipper with power unit on twin axle trailer.
Dimensions:	2.4 m W x 2.74 m H x 6.4 m H (8' x 9' x 21')
	8300 kg (18,300 lbs)
Capacity:	45 cm (18") maximum diameter
	14 ODt per hour (maximum)
Features:	Chain infeed system
	2 knife chipping disk
	318 hp diesel engine
Price:	$132,900 landed in P.E.I.
Comments:	A 1973 model of this chipper is presently being used on P.E.I. by the major chip supplier.

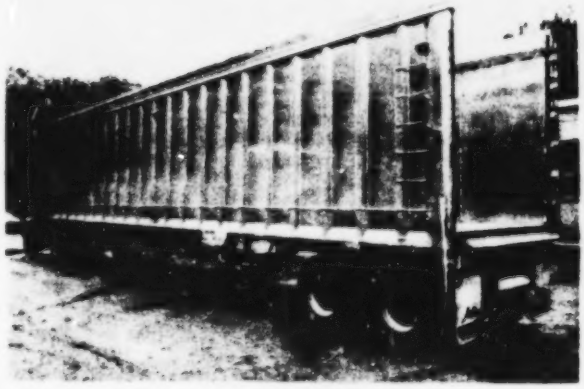


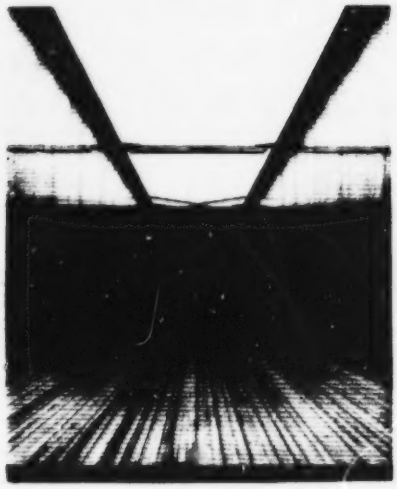
Chipper:	TRELAN DL-18
Supplier:	Atmus Equipment Ltd., Truro, Nova Scotia
Description:	1520 mm (60") disk chipper with power unit on twin axle trailer
Dimensions:	2.4 m W x 3.6 m H x 7.0 m H (3' x 12' x 23')
	13200 kg (29,000 lbs)
Capacity:	45 cm (18") maximum diameter
	16 ODt per hour (maximum)
Features:	Chain infeed system
	2 knife chipping disk
	318 HP diesel engine
	Knuckle boom loader with 18' reach
	Elevated all-weather cab
Price:	$203,000 landed in P.E.I.
Comments:	The unit is based on the D-60 modified to include the operator cap and grapple.

Chipper:	PERUSYHTYMA TT 1000 T[illegible]
Supplier:	Hakmet Ltd., Dorion, Quebec
Description:	1070 mm (42") disk chipper and bin on double axle trailer, powered by tractor PTO shaft.
Dimensions:	2.5 m W x 3.8 m H x 7.6 m H (8' x 12.5' x 25')
	7000 kg (15,400 lbs) without grapple.
Capacity:	26 cm (10") maximum diameter 4-6 ODt per hour
Features:	Bottom feed conveyor and hydraulic top roller 2 knife chipping disk Requires 80-150 hp drive unit 3 ODt chip container with 3.1 m (10') dumping height (optional)
Price:	$100,000 F.O.B. Dorion with bin on chassis $ 47,000 F.O.B. Dorion on trailer without bin Add $20,000 F.O.B. Dorion for 5.5m (18') reach industrial grapple
Comments:	The chipper unit is presently being used for chipping hybrid poplars in Eastern Ontario. Chip quality was very good to excellent in 1984.

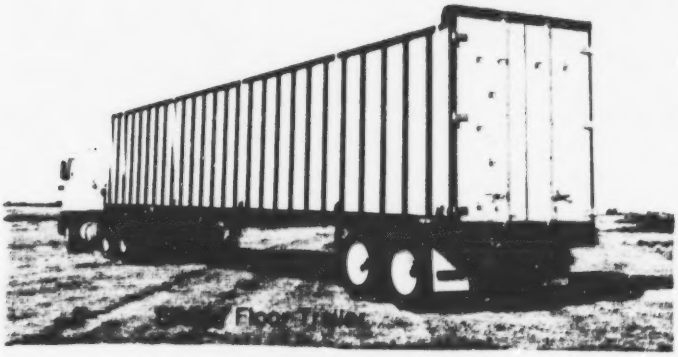


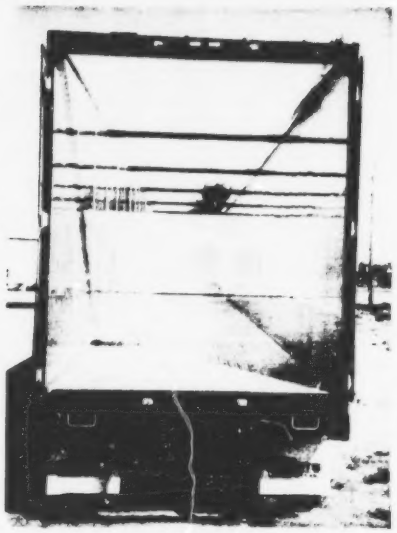
Chipper:	PERUSYHTYMA TT 1500 LP
Supplier:	Hakmet Ltd., Dorion, Quebec
Description:	1500 mm (59") disk chipper unit for mounting on truck or trailor.
Dimensions:	On truck 2.5 m W x 4.0 m H x 10 m L (8'x13'x33') 16,000 kg (35,200 lbs) without vehicle.
Capacity:	45 cm (17") maximum diameter 12-20 ODt per hour
Features:	Bottom conveyor and top hydraulic roller feed. 3 knife chipping disk 300 Hp diesel engine Knuckle boom loader Hydraulically elevated, all-weather operator's cabin. Chipper swivels 45° each way
Price:	$340,000 for Dorion, chipping unit. $400,000 turn-key unit mounted on double axle truck





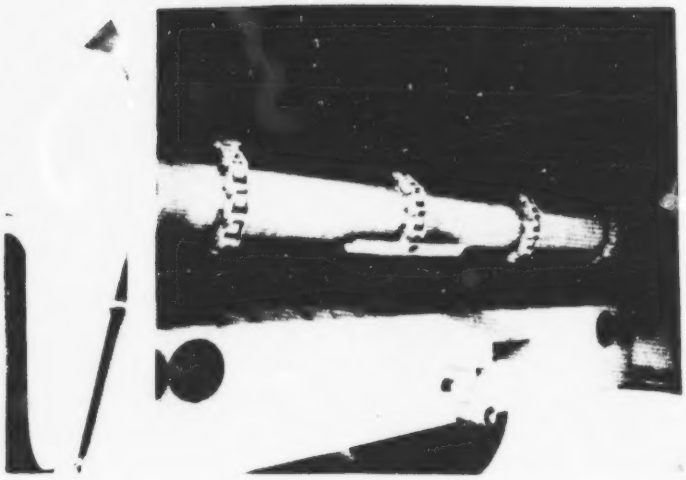
Trailer Type:	Sliding Floor Van
Supplier:	Tusco Trailer & Utility Supply Ltd., London, Ontario
Unloading Mechanism:	Two way moving hydraulic slats and power unit cycle at 6' per minute, 85,000 lbs capacity, 8-12 minute unloading time
Dimensions:	Outside 102" W x 162" H x 48' L (estimated)
Capacity:	3400 cu.ft., 15 ODt
Features:	Open top trailer 2 axles Complete van
Price:	$67,000 F.O.B. London 96" x 45' retrofit of trailer for $28,000
Comments:	A number of these trucks are operating in Nova Scotia





Trailer Type:	Sliding Floor Van
Supplier:	BOCATS, Kansas, U.S.A.
Unloading Mechanism:	Two way moving hydraulic slats and power unit cycle at 6' per minute
	Unloads in 8-12 minutes
Dimensions:	Outside 102" W x 162" H x 40' L Inside 98" W x 103" H x 39' L
	Outside 102" W x 162" H x 50' L Inside 98" W x 108" H x 49' L
Capacity:	40': 2800 cu.ft., 13 ODt
	50': 3600 cu.ft., 16 ODt
Features:	Tarp and rolling mechanism
	10:00 x 20" tires
	2 axles
Price:	40': $46,000 Can. F.O.B. (Duty not included)
	50': $55,000 Can. F.O.B. (Duty not included)

Trailer Type:	Live Bottom Van
Supplier:	BOCATS, Kansas, U.S.A.
Unloading Mechanism:	3-48,000 lb tensile strength chains with 3" wide slats and power unit move at 8' per minute
Dimensions:	Outside 102" W x 162" H x 40' L Inside 96" W x 108" H x 39' L
	Outside 102" W x 162" H x 50' L Inside 96" W x 108" H x 49' L
Capacity:	40': 2800 cu.ft., 13 ODt
	50': 3600 cu.ft., 16 ODt
Features:	Tarp and rolling mechanism
	10:00 x 20" tires
	2 axles
Price:	40': $46,000 Can. F.O.B. (Duty not included)
	50': $50,000 Can. F.O.B. (Duty not included)



Trailer Type:	Live Bottom Van
Supplier:	Peerless, Lear Siegler Inc., Arkansas, U.S.A.
Unloading Mechanism:	4-40,000 lb chains with angle flites powered by tractor hydraulics unloads in 4 minutes
Dimensions:	Outside 96' W x 13'6" H x 45' L
	20,600 lbs
Capacity:	2,800 cu.ft., 13 00t
Features:	Tarp or hydraulic flip top
	10:00 x 20" tires
	2 axles
Price:	$50,000 Can. F.O.B. (Duty not included)

Transport Unit: Container Truck System Using Hydraulic Arm

Unloading Mechanism: Hydraulic Arm rolls containers on and off unit and dumps containers.

Dimensions: Containers up to 2.6m W x 2.6m H x 6m L (8.5' x 8.5' x 20') can be handled easily.

Capacity: 38 cu.m. (1360 cu.ft.) 6 ODt per container

Features: Portable Fuel Containers
Pickup and drop off of containers without leaving cab.

Price:

Tandum Truck	$80,000
Loader	25,000
Trailer	20,000
Bins (4)	25,000
	$150,000

Comments

The unit photographed supplies fuel chips to the Boise Cascade Operation in Newcastle. Six containers were utilized in 1984. Containers carried 6-7 ODt.

Transport Unit: Container Truck Used for Waste Disposal

Unloading Mechanism: Containers are pulled on with a cable. Container is either dumped or rolled off.

Dimensions: Standard containers are 2.5m W x 2.5m H x 5m L (8' x 8' x 16')

Capacity: 29 cu.m (1024 cu.ft.), 4 ODt per container

Features: Portable Fuel Containers

Price:

Tandem Truck	$78,000
Loader	22,000
Bins (2)	10,000
	$110,000

Comments: The operator must leave the cab to connect and disconnect the cable. These units are readily available on P.E.I.

Trailer Type:	10 m (33') DUMP TRAILER
Supplier:	King Truck Engineering, Woodstock, Ontario
Unloading Mechanism:	Hydraulic dump powered by tractor.
Dimensions:	32 cu.m (42 yd) box plus extensions to 162" total height Inside box 2.3 m W x 2.4 m H x 9.8 m L (90" x 96" x 32') with extensions.
Capacity:	54 cu.m (1900 cu.ft) or 7 ODt
Features:	Tri-axle Dump trailer
Price:	$40,000 F.O.B. Woodstock with tri-axle $33,000 with tandem axle
Comments:	This type of unit is readily available on P.E.I. with very low utilization during the winter.

Trailer Type:	12 m (40') DUMP TRAILER
Supplier:	Mack Maritime Ltd., Moncton, New Brunswick
Unloading Mechanism:	Hydraulic dump powered by tractor
Dimensions:	52 cu.m (67 yd) box plus extension to 162" total height Inside box: 2.4 m W x 2.4 m H x 11.9 m L (96" x 96" x 39') with extensions.
Capacity:	68 cu.m (2400 cu.ft) or 10 ODt
Features:	Tandem Axle Dump trailer with approximately 10.8 m (33') maximum height when dumping.
Price:	$41,000 F.O.B. New Brunswick
Comments:	This unit would be relatively unstable when dumping in high winds or on rough ground. This type of unit is readily available on P.E.I. with very low utilization during the winter.

APPENDIX 7

Conversion Factors Used In This Report

Conversion Factors

Wood

Average Moisture Content Green Wood	50.0%
Cord Wood and Air to cu.m. solid wood	2.4

Hardwood:

Pounds per green cord	4400
Green cord to green tonnes	2.0
Green cord to oven dry tonnes	1.0
Cu.m to green tonnes	0.833
Cu.m to oven dry tonnes	0.417
Oven dry tonnes to green tonnes	2.000

Softwood:

Pounds per green cord	4000
Green cord to green tonnes	1.818
Green cord to oven dry tonnes	0.909
Cu.m to green tonnes	0.758
Cu.m to oven dry tonnes	0.379
Oven dry tonnes to green tonnes	2.000

Residues: (Assumed Softwood Only)

Average Moisture Content Green Residue	50%
Pound/cu.ft to kg/cu.m	16.01

Density (green fibre and air):	lb/cu.ft	kg/cu.m
Wood	31.25	500.3
Slabs	27.00	432.3
Chips	18.00	288.2
Sawdust	16.00	256.2
Shavings	10.00	160.1

Conversions:

Cords wood to oven/dry tonnes	0.909
Cords slabs to oven/dry tonnes	0.785
Cords chips to oven/dry tonnes	0.524
Cords sawdust to oven/dry tonnes	0.465
Cords shavings to oven/dry tonnes	0.291

Production (% by weight):

Lumber	35%	
Slabs and Trim	40%	
Sawdust	15%	
Shavings	10%	included in unplaned lumber
Logs	100%	

Commercial Conversion

Wood

@ 45% Moisture Content, 70% Furnace Efficiency, Softwood and low value hardwood

Gross Heat:	Cellulose	20,000 KJ/Kg x .55	=	11000 KJ/Kg
	Less Water	2815 x .45	=	1267
	Less Latent H_2O	1300 x .55	=	715
Net Heat:				9018 KJ/Kg
@ 70% Efficiency				6313 KJ/Kg

Oil

Net Heat:	38,500 KJ/L
@ 80% Efficiency	30,800 KJ/L

1 tonne wood = 205 L oil (1 ton wood = 41 gallons)[1]

Price

At 1984 oil prices of 34 cents/L for bulk orders

1 tonne wood @ 45% M.C. = $69.70 ($126.73/ODt)

1 Compare with 217 litres oil/tonne wood @ 48.5% M.C. reported in IEA (1982) at the Kings County Memorial Hospital and 295 litres oil/tonne wood @ 45% M.C. reported in Laplante (1984) at the Madawaska Correctional Centre. (Based on comparisons of 1981/82 and 1982/83 periods assuming 100% substitution).

Residential Conversions

Wood

@ 30% Moisture Content, 70% Furnace Efficiency, Softwood and low value hardwood.

Gross Heat:	Cellulose	20,000 KJ/Kg x .7	14000 KJ/Kg
	Less Water	2815 KJ/Kg x .3	845
	Less Latent H_2O	1300 KJ/Kg x .7	910
Net Heat:			12245 KJ/Kg
@ 70% Efficiency			8572 KJ/Kg

Oil

Net Heat:	38,500 KJ/L
@ 78% Efficiency	30,030 KJ/L

1 tonne wood = 285 L oil (1 ton wood = 57 gallons)

or 1 cu.m wood = 542 Kg = 154 L oil (1 cord wood = 2860 lbs = 82 gallons)

Price

At 1984 oil prices of 37 cents/L

1 tonne wood @ 30% M.C. = $105.45 ($150.64/ODt)

or 1 cord wood @ 30% M.C. = $137.09